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Search for light scalar top-quark pair production in final states with two leptons with the ATLAS detector in $\sqrt{s} = 7$ TeV proton–proton collisions

The ATLAS Collaboration*

CERN, 1211 Geneva 23, Switzerland

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Abstract A search is presented for the pair production of light scalar top quarks in $\sqrt{s} = 7$ TeV proton–proton collisions recorded with the ATLAS detector at the Large Hadron Collider. This analysis uses the full data sample collected during 2011 running that corresponds to a total integrated luminosity of 4.7 fb^{-1} . Light scalar top quarks are searched for in events with two opposite-sign leptons (e, μ), large missing transverse momentum and at least one jet in the final state. No excess over Standard Model expectations is found, and the results are interpreted under the assumption that the light scalar top decays to a b -quark in addition to an on-shell chargino whose decay occurs through a virtual W boson. If the chargino mass is 106 GeV, light scalar top-quark masses up to 130 GeV are excluded for neutralino masses below 70 GeV.

1 Introduction

Weak-scale supersymmetry (SUSY) [1–9] is an extension to the Standard Model (SM) that provides a solution to the instability of the scalar SM sector with respect to new high-scale physics. For each known boson or fermion, SUSY introduces a particle with identical quantum numbers except for a difference of half a unit of spin. In the framework of a generic R -parity conserving minimal supersymmetric extension of the SM (MSSM) [10–14], SUSY particles are produced in pairs and the lightest supersymmetric particle (LSP) is stable. In a large variety of models, the LSP is the lightest neutralino, $\tilde{\chi}_1^0$, which is only weakly interacting. The scalar partners of right-handed and left-handed quarks, \tilde{q}_R and \tilde{q}_L , mix to form two mass eigenstates, \tilde{q}_1 and \tilde{q}_2 , with \tilde{q}_1 defined to be the lighter one. In the case of the su-

persymmetric partner of the top quark (\tilde{t} , stop), large mixing effects can lead to one stop mass eigenstate, \tilde{t}_1 , that is significantly lighter than the other squarks. Depending on the SUSY particle mass spectrum, stop pair production and decay can result in final states topologically similar to $t\bar{t}$ events.

In this Letter, a search for direct stop pair production is presented in $\sqrt{s} = 7$ TeV proton–proton collisions recorded with the ATLAS detector at the Large Hadron Collider, considering a SUSY particle mass hierarchy such that $m_t > m_{\tilde{t}_1} > (m_{\tilde{\chi}_1^\pm} + m_b)$ and the \tilde{t}_1 decays exclusively via $b + \tilde{\chi}_1^\pm$. The mass of all other supersymmetric particles are set to be above 2 TeV, and large stop gauge mixing results in $m_{\tilde{t}_2} \gg m_{\tilde{t}_1}$ so that only \tilde{t}_1 pair production is considered. The stop is predominantly right-handed, but this has little effect on the acceptance and efficiency for the final interpretation. The chargino ($\tilde{\chi}_1^\pm$) mass is set to 106 GeV (above the present exclusion limit of 103.5 GeV [15]) and it is assumed to decay through a virtual W boson ($\tilde{\chi}_1^\pm \rightarrow W^* \tilde{\chi}_1^0$). The choice of chargino mass is identical to that used in a previous study reported by the CDF experiment [16], thus allowing easy comparison of the CDF and ATLAS results. Stops within a mass range between 110 GeV and 160 GeV would be produced with relatively large cross sections—between 245 pb and 41 pb. In this search, dilepton final states ($\ell = e, \mu$) are considered. Although these events could contribute to an anomaly in the measured $t\bar{t}$ cross section, the relative contribution would be small due to the low transverse momenta of the visible decay products. Events are required to contain at least one energetic jet, large missing transverse momentum (E_T^{miss}) and low transverse momenta (p_T) leptons, to target the light stop final state.

By targeting very light top squarks, this analysis is complementary to other direct stop searches recently presented by the ATLAS experiment [17, 18].

* e-mail: atlas.publications@cern.ch

2 The ATLAS detector

The ATLAS detector [19] is a multi-purpose particle physics detector with a forward-backward symmetric cylindrical geometry and nearly 4π coverage in solid angle.¹ It contains four superconducting magnet systems, which comprise a solenoid surrounding the inner tracking detector (ID), and the barrel and two end-cap toroids equipping a muon spectrometer. The ID consists of a silicon pixel detector, a silicon microstrip detector (SCT), and a transition radiation tracker (TRT). In the pseudorapidity region $|\eta| < 3.2$, high-granularity liquid-argon (LAr) electromagnetic (EM) sampling calorimeters are used. An iron/scintillator tile calorimeter provides coverage for hadron detection over $|\eta| < 1.7$. The end-cap and forward regions, spanning $1.5 < |\eta| < 4.9$, are instrumented with LAr calorimeters for both EM and hadronic measurements. The muon spectrometer surrounds the calorimeters and consists of a system of precision tracking chambers ($|\eta| < 2.7$), and detectors for triggering ($|\eta| < 2.4$).

3 Simulated event samples

Monte Carlo (MC) simulated event samples are used to develop and validate the analysis procedure and to evaluate the SM backgrounds in the signal region. Production of top quark pairs is simulated with MC@NLO 4.01 [20–22], using a top-quark mass of 172.5 GeV. Samples of $W(\rightarrow \ell\nu)$ and $Z/\gamma^*(\rightarrow \ell\ell)$, produced with accompanying jets (of both light and heavy flavour), are obtained with ALPGEN 2.14 [23]. Diboson (WW , WZ , ZZ) production is simulated with HERWIG 6.520 [24] and single top production with MC@NLO 4.01. Fragmentation and hadronisation for the ALPGEN 2.14 and MC@NLO 4.01 samples are performed with HERWIG 6.520, using JIMMY 4.31 [25] for the underlying event. Expected diboson yields are normalised using next-to-leading-order (NLO) QCD predictions obtained with MCFM [26, 27]. The top-quark contribution is normalised to approximate next-to-next-to-leading-order (NNLO) calculations [28]. The inclusive W and Z/γ^* production cross sections are normalised to the NNLO cross sections obtained using FEWZ [29]. ALPGEN 2.14 and POWHEG [30] samples are used to assess the systematic uncertainties associated with the choice of generator for $t\bar{t}$ production, and AcerMC [31] samples are used to assess

the uncertainties associated with initial- and final-state radiation (ISR/FSR) [32]. The choice of the parton distribution functions (PDFs) depends on the generator. CT10 [33] sets are used for all MC@NLO samples. MRST LO** [34] sets are used with HERWIG and PYTHIA, and CTEQ6L1 [35] with ALPGEN 2.14. The stop production models are simulated using PYTHIA 6.425 [36]. Signal cross sections are calculated to next-to-leading order in the strong coupling constant, including the resummation of soft gluon emission at next-to-leading-logarithmic accuracy (NLO + NLL) [37–39]. An envelope of cross-section predictions is defined using the 68 % C.L. ranges of the CTEQ6.6 (including the α_S uncertainty) and MSTW 2008 NLO [40] PDF sets, together with independent variations of the factorisation and renormalisation scales by factors of two or one half. The nominal cross-section value is taken to be the midpoint of the envelope and the uncertainty assigned is half the full width of the envelope, following the PDF4LHC recommendations [41]. All MC samples are produced using a GEANT4-based [42] detector simulation [43]. The effect of multiple proton–proton collisions from the same or different bunch crossings is incorporated into the simulation by overlaying additional PYTHIA minimum bias events onto hard-scattering events. Simulated events are weighted to match the distribution of the mean number of interactions per bunch crossing observed in data.

4 Data and event selection

The analysis uses the full 2011 proton-proton collision data sample. After applying the beam, detector and data-quality requirements, the data sample corresponds to a total integrated luminosity of 4.7 fb^{-1} . Events were triggered using a combination of single and double lepton triggers. The single electron triggers vary with the data-taking period, and the tightest of these has an efficiency of $\sim 97\%$ for electrons with $p_T > 25 \text{ GeV}$. The single muon trigger used for all data-taking periods reaches an efficiency plateau of $\sim 75\%$ ($\sim 90\%$) in the barrel (end-caps) for muons with $p_T > 20 \text{ GeV}$. All efficiencies are quoted with respect to reconstructed leptons, passing the baseline lepton definitions. The double lepton triggers reach similar plateau efficiencies, but at lower p_T thresholds (greater than 17 GeV for electrons passing the dielectron trigger, and greater than 12 GeV for muons passing the dimuon trigger; for the electron-muon trigger the thresholds are 15 and 10 GeV for electrons and muons, respectively). If a lepton has an offline p_T above the single lepton trigger plateau threshold in a given event, the relevant single lepton trigger is used. Double lepton triggers are used for events with no such lepton. An exception to this rule is applied in the $\mu\mu$ channel. In this case when one lepton has $p_T > 20 \text{ GeV}$ and the second

¹ATLAS uses a right-handed coordinate system with its origin at the nominal interaction point in the centre of the detector and the z -axis along the beam pipe. Cylindrical coordinates (r, ϕ) are used in the transverse plane, ϕ being the azimuthal angle around the beam pipe. The pseudorapidity η is defined in terms of the polar angle θ by $\eta = -\ln \tan(\theta/2)$.

$p_T > 12$ GeV, a logical OR of both triggers is used to recover efficiency.

Jet candidates are reconstructed using the anti- k_t jet clustering algorithm [44] with a radius parameter of 0.4. The input to this algorithm is the three-dimensional energy clusters seeded by calorimeter cells with energy significantly above the noise resulting from the electronics and additional proton–proton interactions (calorimeter clusters). The jet candidate energies are corrected for the effects of calorimeter non-compensation, inhomogeneities and energy loss in material in front of the calorimeter, by using p_T - and η -dependent calibration factors based on MC simulations and validated with extensive test-beam and collision-data studies [45]. Furthermore, the reconstructed jet is modified such that the jet direction points to the primary vertex, defined as the vertex with the highest summed track p_T^2 . Only jet candidates with corrected transverse momenta $p_T > 20$ GeV and $|\eta| < 4.5$ are subsequently retained. Jets likely to have arisen from detector noise or cosmic rays are rejected [45]. Electron candidates are required to have $p_T > 10$ GeV, $|\eta| < 2.47$, and pass the “medium” shower shape and track selection criteria of Ref. [46]. Muon candidates are reconstructed using either a full muon spectrometer track matched to an ID track, or a muon spectrometer segment matched to an extrapolated ID track [47]. They must be reconstructed with sufficient hits in the pixel, SCT and TRT detectors. They are required to have $p_T > 10$ GeV and $|\eta| < 2.4$.

Following object reconstruction, overlaps between candidate jets and leptons are resolved. Any jet candidate lying within a distance $\Delta R = \sqrt{(\Delta\eta)^2 + (\Delta\phi)^2} = 0.2$ of an electron is discarded. Subsequently, any electron or muon candidate remaining within a distance $\Delta R = 0.4$ of any surviving jet candidate is discarded.

The measurement of the missing transverse momentum $\mathbf{p}_T^{\text{miss}}$, and its magnitude E_T^{miss} , is based on the transverse momenta of all electrons, muons and jets as described above, and of all calorimeter clusters with $|\eta| < 4.5$ not associated to such objects.

Following overlap removal, electrons are further required to have $p_T > 17$ GeV and to pass the “tight” [46] quality criteria, which places additional requirements on the ratio of calorimetric energy to track momentum, and the fraction of high-threshold hits in the TRT. Electrons are also required to be isolated: the p_T sum of tracks above 1 GeV within a cone of size $\Delta R = 0.2$ around each electron candidate (excluding the electron candidates themselves) is required to be less than 10 % of the electron p_T . Muons must have $p_T > 12$ GeV and must be isolated: the p_T sum of tracks within a cone of size $\Delta R = 0.2$ around the muon candidate is required to be less than 1.8 GeV. Jets are subject to the fur-

ther requirements $p_T > 25$ GeV, $|\eta| < 2.5$ and a “jet vertex fraction”² higher than 0.75.

The top background measurement described below uses a b -tagging algorithm [48], which exploits the topological structure of weak b - and c -hadron decays inside a candidate jet to identify jets containing a b -hadron decay. The nominal b -tagging efficiency, computed from $t\bar{t}$ MC events, is on average 60 %, with a misidentification (mis-tag) rate for light-quark/gluon jets of less than 1 %. To correct small differences in the b -tagging efficiency observed in the simulation with respect to the data, a scale factor is applied to all simulated samples.

During part of the data-taking period, a localised electronics failure in the electromagnetic calorimeter created a dead region ($\Delta\eta \times \Delta\phi \approx 1.4 \times 0.2$). For jets in this region, a correction to their energy is made using the energy depositions in the neighbouring cells, and is propagated to E_T^{miss} . If the energy correction exceeds 10 GeV or 10 % of the E_T^{miss} , the event is discarded. Events with reconstructed electrons in the calorimeter dead region are also rejected.

Events are subject to the following requirements. The primary vertex in the event must have at least five associated tracks and each event must contain exactly two selected leptons (electrons or muons) of opposite sign. Both of these leptons must additionally satisfy the full list of signal lepton requirements, and the dilepton invariant mass, m_{ll} , must be greater than 20 GeV across all flavour combinations. In addition, events in the signal region must have at least one jet with $p_T > 25$ GeV, $E_T^{\text{miss}} > 20$ GeV, missing transverse momentum significance³ $E_T^{\text{miss, sig}} > 7.5 \text{ GeV}^{1/2}$ to reject multijet events, and leading lepton $p_T < 30$ GeV (to provide further rejection of the dominant dileptonic $t\bar{t}$ background). Events in the ee and $\mu\mu$ channels are subject to a further requirement on the dilepton invariant mass to reject events arising from Z production and decay. This selection, summarised in Table 1, has a low signal efficiency, but strong background rejection. The main factor in the efficiency loss is the lowest lepton p_T requirement needed to reach the efficiency plateau of the dilepton triggers. The kinematic acceptance varies between 0.06 % and 0.3 % for a neutralino mass of 55 GeV as the stop mass varies between 112 GeV and 180 GeV, and between 0.1 % and 0.003 % for a stop mass of 140 GeV as the neutralino mass varies between 1 GeV and 95 GeV (the detector efficiency for these points, defined as the efficiency for recon-

²The jet vertex fraction quantifies the fraction of track transverse momentum associated to a jet which comes from the primary vertex. The cut removes jets within the tracker acceptance which originated from uncorrelated soft collisions.

³In this paper, $E_T^{\text{miss, sig}} = E_T^{\text{miss}} / \sqrt{H_T}$, where H_T is the scalar sum of the jet and lepton transverse momenta in each event.

Table 1 Signal region, top control region and Z control region requirements in each flavour channel. The Z veto rejects events with $m_{ll} > 81$ GeV and $m_{ll} < 101$ GeV

Requirement	ee channel	$\mu\mu$ channel	$e\mu$ channel
Signal Region			
lepton p_T	> 17 GeV	> 12 GeV	$> 17(12)$ GeV for $e(\mu)$
leading lepton p_T		< 30 GeV	
m_{ll}	> 20 GeV and Z veto		> 20 GeV
jet p_T		≥ 1 jet, $p_T > 25$ GeV	
E_T^{miss}		> 20 GeV	
$E_T^{\text{miss,sig}}$		$> 7.5 \text{ GeV}^{1/2}$	
Top Control Region			
lepton p_T	> 17 GeV	> 12 GeV	$> 17(12)$ GeV for $e(\mu)$
leading lepton p_T		> 30 GeV	
m_{ll}	> 20 GeV and Z veto		> 20 GeV
jet p_T		≥ 2 (b)jets, $p_T > 25$ GeV	
b -jet p_T		≥ 1 b jet, $p_T > 25$ GeV	
E_T^{miss}		> 20 GeV	
$E_T^{\text{miss,sig}}$		$> 7.5 \text{ GeV}^{1/2}$	
Z Control Region			
lepton p_T	> 17 GeV	> 12 GeV	n/a
leading lepton p_T		< 30 GeV	n/a
m_{ll}	> 81 GeV and < 101 GeV		n/a
jet p_T	≥ 1 jet, $p_T > 25$ GeV		n/a
E_T^{miss}	> 20 GeV		n/a
$E_T^{\text{miss,sig}}$	$> 4.0 \text{ GeV}^{1/2}$		n/a

structing events that already enter the kinematic acceptance, is ~ 40 %).

5 Background estimation

The dominant SM background, after the signal selection requirements, arises from $t\bar{t}$ events where both top quarks decay leptonically, with the next most significant background being $Z/\gamma^* + \text{jets}$. Single top, $W + \text{jets}$, diboson and multi-jet events give much smaller expected contributions.

The fully leptonic $t\bar{t}$ background in the signal region is obtained by extrapolating the number of $t\bar{t}$ events measured in a suitable control region (CR), after correcting for contamination from non- $t\bar{t}$ events, into the signal region (SR). This extrapolation, detailed in Eq. (1), uses the ratio of the number of simulated $t\bar{t}$ events in the signal region to those in the control region:

$$(N_{t\bar{t}})_{\text{SR}} = [(N_{\text{data}})_{\text{CR}} - (N_{\text{non-}t\bar{t},\text{MC}})_{\text{CR}}] \frac{(N_{t\bar{t},\text{MC}})_{\text{SR}}}{(N_{t\bar{t},\text{MC}})_{\text{CR}}} \quad (1)$$

The CR is designed to give an event sample dominated by top events, whilst minimising signal contamination. It is further chosen to be kinematically similar to the signal region to minimise systematic uncertainties due to extrapolation. Selection requirements for the top control region are

summarised in Table 1. In this analysis, models with small stop–chargino mass difference are considered, and hence soft b -jets are expected in the signal events which are not efficiently tagged. By requiring a b -jet in the top control region a high-purity sample of top events is obtained. The signal contamination in the considered models is typically of the order of a few per cent, rising to 30 % for models with $m_{\tilde{\chi}_1^0} = 1$ GeV and high $m_{\tilde{t}_1}$. The percentage of SM, non- $t\bar{t}$ events in the CR is less than 5 % across all channels. The resulting $t\bar{t}$ background contributions are consistent with the expected MC yields in all channels within the uncertainties. Signal contamination is taken into account when setting the exclusion limit in the next section by including, for each signal model, the expected signal yield in the top control region in the $(N_{\text{non-}t\bar{t},\text{MC}})_{\text{CR}}$ term in Eq. (1).

The contribution from $Z/\gamma^* + \text{jets}$ events to the signal region (from ee and $\mu\mu$ events) is evaluated in a similar way. Data are used to obtain the normalisation of the Z/γ^* background in a suitable CR and MC is used to extrapolate from CR to SR using an equation analogous to Eq. (1). This method is used separately for each of the ee and $\mu\mu$ channels (with selection requirements for the Z CR as summarised in Table 1), whereas the contribution to $e\mu$ (including those from $Z/\gamma^* \rightarrow \tau\tau$) is taken directly from the MC simulation due to the limited number of events in the CR.

The contamination from non- $Z/\gamma^* + \text{jets}$ SM events in the CR is less than 5 %, and the signal contamination less than 4 %. The resulting Z background contributions are consistent with the expected MC yields in the ee and $\mu\mu$ channels within the uncertainties. The effect of signal contamination of the Z control region on the final exclusion limit can be neglected to a very good approximation.

Single top, $W + \text{jets}$ (including heavy-flavour contributions) and diboson backgrounds are evaluated in the signal region directly from the MC simulation. The estimated contribution from $W + \text{jets}$ has been cross-checked using a data-driven technique (an extension of the “template fit”, described below), and found to be in good agreement.

The tight requirement on $E_T^{\text{miss, sig}}$ heavily suppresses the multijet background. A data-driven template fit technique is used to verify that this background is small, and to assign an uncertainty on the yield in the signal region. The isolation requirements on the electrons and muons are reversed to enhance the multijet content of selected events. The requirements are inverted in the signal region, prior to application of the $E_T^{\text{miss, sig}}$ requirement. The shape of the $E_T^{\text{miss, sig}}$ distribution in data for this inverted selection (after subtracting the dominantly electroweak background using the MC simulation) is then compared to the equivalent distribution in data for the “normal” isolation requirements in order to validate that inverting the lepton isolation does not distort the shape of the distribution. The “normal” and “inverted” shapes were found to agree very closely for the full range of distributions considered in the analysis. The inverted $E_T^{\text{miss, sig}}$ distribution is then renormalised to match the distribution after nominal isolation requirements. Passing this correctly normalised template through the remaining requirements gives the multijet yield in the signal region. It is found to be small in all channels, making up less than 2 % of the total background.

6 Systematic uncertainties

The total systematic uncertainty on the expected background in the combined flavour channel (the sum of ee , $e\mu$ and $\mu\mu$ events) is 9.8 %, and is dominated by the uncertainties on the two largest backgrounds (dileptonic $t\bar{t}$ and $Z + \text{jet}$ events). The largest source of systematic uncertainty on the $t\bar{t}$ background evaluation is the uncertainty on the jet energy scale (JES), with smaller contributions coming from the jet energy resolution (JER) uncertainty [45], the theory and MC modelling uncertainties (using the prescriptions described in Ref. [49]), the systematic uncertainties on the b -tagging efficiency [48], and the uncertainty arising from the limited numbers of MC and data events. Uncertainties [46, 50, 51] in lepton reconstruction and identification (momentum and

energy scales, resolutions and efficiencies) give smaller contributions.

The primary source of uncertainty on the $Z/\gamma^* + \text{jets}$ background estimate in the combined flavour channel is the jet energy resolution uncertainty, with smaller contributions coming from the statistical and jet energy scale uncertainties. Theoretical uncertainties on the $Z/\gamma^* + \text{jets}$ background are investigated by varying the PDF and renormalisation scales. An uncertainty on the luminosity of 3.9 % [52, 53] is included in the systematic uncertainty calculation for backgrounds taken directly from the MC simulation. The dominant uncertainties on these backgrounds are the jet energy scale and statistical uncertainties. The systematic uncertainty on the multijet yield is obtained by varying the range in which the template fit is performed, and using the maximum deviation of the final yield to assign the uncertainty.

In the considered $m_{\tilde{\chi}_1^0} - m_{\tilde{t}_1}$ mass plane the theoretical uncertainty on each of the signal cross sections is approximately 16 %. These arise from considering the cross-section envelope defined using the 68 % C.L. ranges of the CTEQ6.6 and MSTW 2008 NLO PDF sets, and independent variations of the factorisation and renormalisation scales (see Sect. 3). Further uncertainties on the numbers of predicted signal events arise from the JES uncertainty (7–15 %), the JER uncertainty (1–7 %), the luminosity uncertainty (3.9 %), the uncertainties on calorimeter energy clusters used to calculate E_T^{miss} (2–6 %), the statistical uncertainty from finite MC event samples (4–20 %) and smaller contributions from uncertainties on lepton reconstruction and identification, where the quoted ranges display the maximum variation observed using all signal models considered in this analysis.

7 Results and interpretation

Table 2 shows the data observations in the signal regions in each flavour channel, and in the combined flavour channel, along with the evaluated background contributions. Good agreement is observed across all channels, and the absence of evidence for light scalar top production allows a limit to be set on the visible cross section for non-SM physics, $\sigma_{\text{vis}} = \sigma \times \epsilon \times A$, for which this analysis has an efficiency ϵ and acceptance A . The limits are calculated using the modified frequentist CL_s prescription [54] by comparing the number of observed events in data with the SM and SM-plus-signal expectations.

All systematic uncertainties and their correlations are taken into account via nuisance parameters using a profile likelihood technique [55]. In Fig. 1, the leading lepton p_T distributions in the ee and $\mu\mu$ channels are illustrated along

Table 2 The expected and observed numbers of events in the signal region for each flavour channel. In the combined flavour column (“all”), the statistical uncertainty (first uncertainty quoted, includes the MC and data statistical errors) on the various background estimates have each been added in quadrature whilst the systematic uncertainties (second uncertainty quoted) have been combined taking into account

the correlations between background sources. Observed and expected upper limits at 95 % confidence level on the visible cross section $\sigma_{\text{vis}} = \sigma \times A \times \epsilon$ are also shown. The expected signal yields and statistical uncertainties on the yields are quoted for the two mass points illustrated in the figures

	ee	$e\mu$	$\mu\mu$	all
$t\bar{t}$	$44 \pm 4 \pm 5$	$139 \pm 7 \pm 22$	$111 \pm 8 \pm 10$	$293 \pm 12 \pm 34$
$Z/\gamma^* + \text{jets}$	$5 \pm 1 \pm 2$	$23 \pm 2 \pm 8$	$48 \pm 16 \pm 27$	$76 \pm 16 \pm 27$
Single top	$3 \pm 0.5 \pm 1$	$12 \pm 1 \pm 2$	$12 \pm 1 \pm 2$	$28 \pm 2 \pm 5$
$W + \text{jets}$	$3 \pm 3 \pm 3$	$5 \pm 2 \pm 1$	$6 \pm 2 \pm 1$	$13 \pm 3 \pm 3$
Diboson	$4 \pm 0.4 \pm 0.5$	$9 \pm 0.7 \pm 2$	$10 \pm 0.7 \pm 1$	$22 \pm 1 \pm 3$
Multijet	$2.9^{+3.2}_{-2.9} \pm 2.2$	$2.0 \pm 1.4 \pm 0.3$	$3.0 \pm 2.8 \pm 0.3$	$8.0 \pm 3.7 \pm 2.3$
Total	$61 \pm 6 \pm 6$	$189 \pm 8 \pm 21$	$190 \pm 19 \pm 31$	$440 \pm 21 \pm 43$
Data	48	188	195	431
σ_{vis} (exp. limit) [fb]	4.9	11.1	16.2	22.0
σ_{vis} (obs. limit) [fb]	3.3	10.9	16.9	21.0
$(m_{\tilde{t}_1}, m_{\tilde{\chi}_1^0}) = (112, 55)$ GeV	44.1 ± 4.8	137 ± 8	140 ± 8	322 ± 13
$(m_{\tilde{t}_1}, m_{\tilde{\chi}_1^0}) = (160, 55)$ GeV	8.8 ± 1.5	31.4 ± 2.7	36.5 ± 2.9	76.6 ± 4.3

with the E_T^{miss} and $E_T^{\text{miss, sig}}$ distributions of the data and simulated events in the signal region (with the background normalisations set to their nominal values).

The observed data yield is in good agreement with the SM prediction in the combined flavour channel given in Table 2.

The results in the combined channel are used to place exclusions at 95 % confidence level in the $m_{\tilde{t}_1} - m_{\tilde{\chi}_1^0}$ mass plane, using the CL_s method. The resulting 95 % confidence level expected (dashed) and observed (solid) limits are shown in Fig. 2. Neutralino masses down to 1 GeV are considered, since there is no LEP limit on the neutralino mass in the MSSM for the case that the lightest neutralino is predominantly bino in nature. A bino-dominated lightest neutralino is favoured by the recent LHC Higgs search results.

The observed limits represent a significant extension of the CDF limit [16] for a chargino mass of 106 GeV to smaller chargino minus neutralino mass difference (the ATLAS limit extends up to a neutralino mass of 70 GeV for a stop mass of 130 GeV, whilst the CDF limit extends up to a neutralino mass of 46 GeV).

The limit on the stop mass for neutralino masses of 45 GeV (135 GeV) is comparable to the equivalent CDF limit. Increasing the chargino mass by 15 GeV leads to a modest shift of the exclusion limit to higher values of the neutralino mass, with the reach in stop mass being enhanced to a lesser degree due to the falling stop production cross section. For example, for a model with $m_{\tilde{t}_1} = 130$ GeV, $m_{\tilde{\chi}_1^\pm} = 120$ GeV and $m_{\tilde{\chi}_1^0} = 60$ GeV, the value of $A \times \epsilon$

(0.032 %) is slightly higher than for the equivalent model with $m_{\tilde{\chi}_1^\pm} = 106$ GeV (0.026 %).

8 Conclusions

A search for light top squarks has been performed in the dilepton final state. SM backgrounds have been evaluated using a combination of data-driven techniques and MC simulation. Good agreement is observed between data and the SM prediction in all three flavour channels. The results are interpreted in the $m_{\tilde{t}_1} - m_{\tilde{\chi}_1^0}$ plane with the chargino mass set to 106 GeV, and with the assumption that the decay $\tilde{t}_1 \rightarrow b\tilde{\chi}_1^\pm$ occurs 100 % of the time, followed by decay via a virtual W ($\tilde{\chi}_1^\pm \rightarrow W^*\tilde{\chi}_1^0$) with an 11 % branching ratio (per flavour channel) to decay leptonically. A lower limit at 95 % confidence level is set on the stop mass in this plane using the combined flavour channel. This excludes stop masses up to 130 GeV (for neutralino masses between 1 GeV and 70 GeV). This limit exceeds that set by the CDF Collaboration for the same scenario [16].

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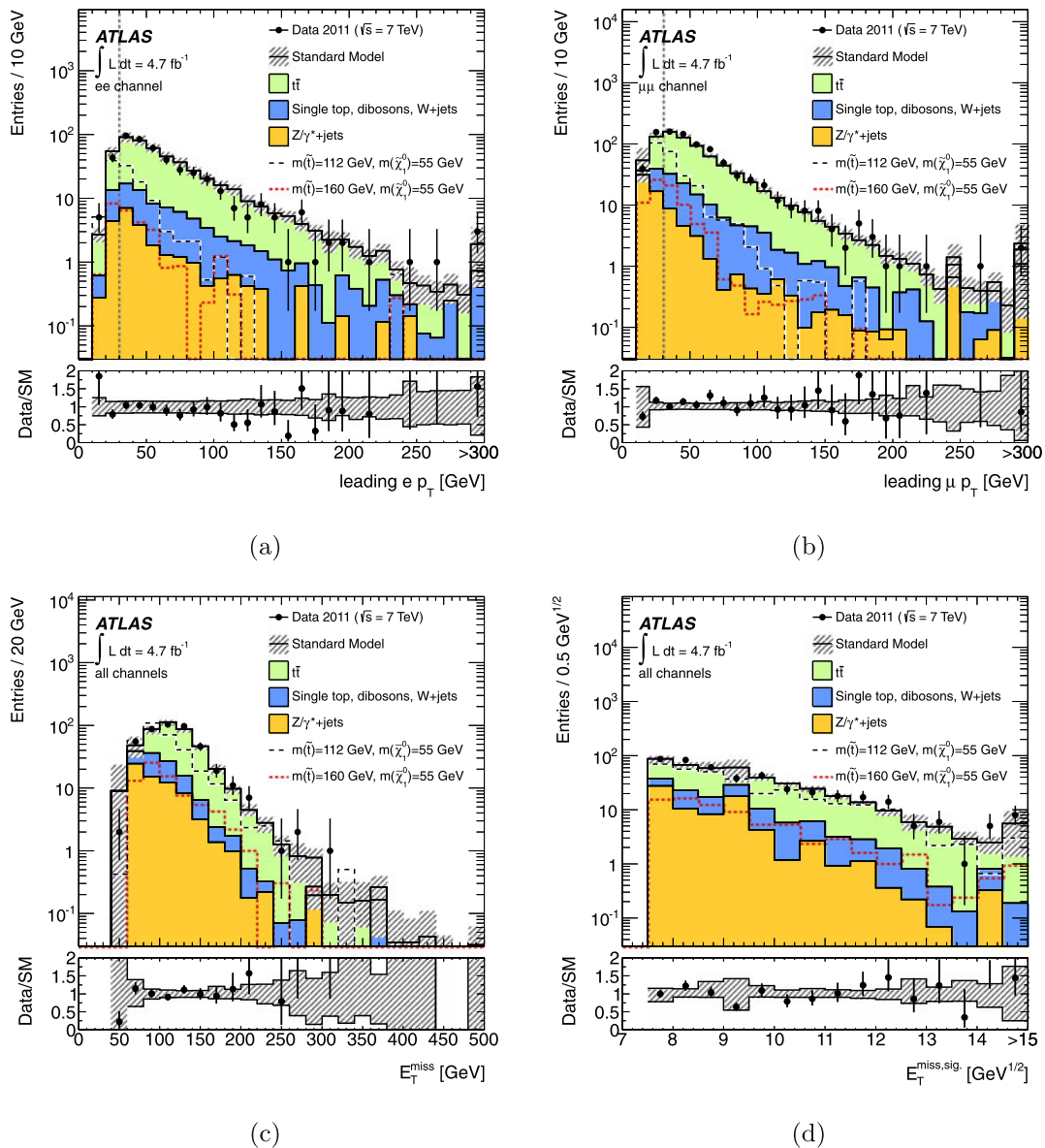


Fig. 1 The leading electron and muon p_T distributions in the same flavour (a) ee and (b) $\mu\mu$ channels, before the requirement on the leading lepton p_T (which is marked by the dashed vertical line), and (c) the E_T^{miss} distribution and (d) $E_T^{miss,sig}$ distribution after all signal region requirements. The data and evaluated background components are shown. The hashed band indicates the total experimental uncertainty on the expectation. The dashed lines give the expectations for

signal models with stop masses of 112 GeV and 160 GeV, and a neutralino mass of 55 GeV. The last histogram bins in (a) and (b) include the integrals of all events with $p_T > 300$ GeV. The final bin in (d) includes all events with an $E_T^{miss,sig}$ of at least 15 GeV $^{1/2}$. The bottom panels show the ratio of the data to the expected background (points) and the systematic uncertainty on the background (hashed area)

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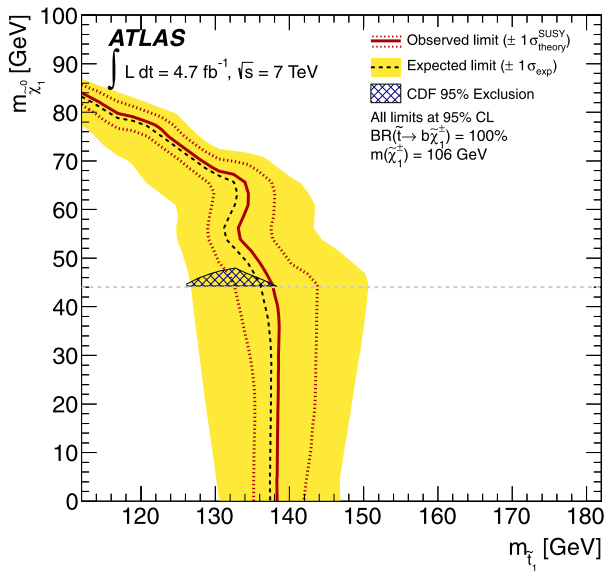


Fig. 2 95 % exclusion limit in the $m_{\tilde{t}_1} - m_{\tilde{\chi}_1^0}$ mass plane, with $m_{\tilde{\chi}_1^\pm} = 106$ GeV. The dashed and solid lines show the 95 % C.L. expected and observed limits, respectively, including all uncertainties except for the theoretical signal cross-section uncertainty (PDF and scale). The band around the expected limit shows the $\pm 1\sigma$ result. The dotted $\pm 1\sigma$ lines around the observed limit represent the results obtained when moving the nominal signal cross section up or down by the theoretical uncertainty. Illustrated also is the region excluded at the 95 % C.L. by CDF [16], where the lowest neutralino mass considered was 44 GeV, indicated by the horizontal dotted line

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The ATLAS Collaboration

G. Aad⁴⁷, T. Abajyan²⁰, B. Abbott¹¹⁰, J. Abdallah¹¹, S. Abdel Khalek¹¹⁴, A.A. Abdelalim⁴⁸, O. Abdinov¹⁰, R. Aben¹⁰⁴, B. Abi¹¹¹, M. Abolins⁸⁷, O.S. AbouZeid¹⁵⁷, H. Abramowicz¹⁵², H. Abreu¹³⁵, E. Acerbi^{88a,88b}, B.S. Acharya^{163a,163b}, L. Adamczyk³⁷, D.L. Adams²⁴, T.N. Addy⁵⁵, J. Adelman¹⁷⁵, S. Adomeit⁹⁷, P. Adragna⁷⁴, T. Adye¹²⁸, S. Aefsky²², J.A. Aguilar-Saavedra^{123b,a}, M. Agustoni¹⁶, M. Aharrouche⁸⁰, S.P. Ahlen²¹, F. Ahles⁴⁷, A. Ahmad¹⁴⁷, M. Ahsan⁴⁰, G. Aielli^{132a,132b}, T. Akdogan^{18a}, T.P.A. Åkesson⁷⁸, G. Akimoto¹⁵⁴, A.V. Akimov⁹³, M.S. Alam¹, M.A. Alam⁷⁵, J. Albert¹⁶⁸, S. Albrand⁵⁴, M. Aleksa²⁹, I.N. Aleksandrov⁶³, F. Alessandria^{88a}, C. Alexa^{25a}, G. Alexander¹⁵², G. Alexandre⁴⁸, T. Alexopoulos⁹, M. Alhroob^{163a,163c}, M. Aliev¹⁵, G. Alimonti^{88a}, J. Alison¹¹⁹, B.M.M. Allbrooke¹⁷, P.P. Allport⁷², S.E. Allwood-Spiers⁵², J. Almond⁸¹, A. Aloisio^{101a,101b}, R. Alon¹⁷¹, A. Alonso⁷⁸, F. Alonso⁶⁹, B. Alvarez Gonzalez⁸⁷, M.G. Alviggi^{101a,101b}, K. Amako⁶⁴, C. Amelung²², V.V. Ammosov^{127,*}, A. Amorim^{123a,b}, N. Amram¹⁵², C. Anastopoulos²⁹, L.S. Ancu¹⁶, N. Andari¹¹⁴, T. Andeen³⁴, C.F. Anders^{57b}, G. Anders^{57a}, K.J. Anderson³⁰, A. Andreazza^{88a,88b}, V. Andrei^{57a}, M.-L. Andrieux⁵⁴, X.S. Anduaga⁶⁹, P. Anger⁴³, A. Angerami³⁴, F. Anghinolfi²⁹, A. Anisenkov¹⁰⁶, N. Anjos^{123a}, A. Anovi⁴⁶, A. Antonaki⁸, M. Antonelli⁴⁶, A. Antonov⁹⁵, J. Antos^{143b}, F. Anulli^{131a}, M. Aoki¹⁰⁰, S. Aoun⁸², L. Aperio Bella⁴, R. Apolle^{117,c}, G. Arabidze⁸⁷, I. Aracena¹⁴², Y. Arai⁶⁴, A.T.H. Arce⁴⁴, S. Arfaoui¹⁴⁷, J.-F. Arguin¹⁴, E. Arik^{18a,*}, M. Arik^{18a}, A.J. Armbruster⁸⁶, O. Arnaez⁸⁰, V. Arnal⁷⁹, C. Arnault¹¹⁴, A. Artamonov⁹⁴, G. Artoni^{131a,131b}, D. Arutinov²⁰, S. Asai¹⁵⁴, R. Asfandiyarov¹⁷², S. Ask²⁷, B. Åsman^{145a,145b}, L. Asquith⁵, K. Assamagan²⁴, A. Astbury¹⁶⁸, B. Aubert⁴, E. Auge¹¹⁴, K. Augsten¹²⁶, M. Aurousseau^{144a}, G. Avolio¹⁶², R. Avramidou⁹, D. Axen¹⁶⁷, G. Azuelos^{92,d}, Y. Azuma¹⁵⁴, M.A. Baak²⁹, G. Baccaglioni^{88a}, C. Bacci^{133a,133b}, A.M. Bach¹⁴, H. Bachacou¹³⁵, K. Bachas²⁹, M. Backes⁴⁸, M. Backhaus²⁰, E. Badescu^{25a}, P. Bagnaia^{131a,131b}, S. Bahinipati², Y. Bai^{32a}, D.C. Bailey¹⁵⁷, T. Bain¹⁵⁷, J.T. Baines¹²⁸, O.K. Baker¹⁷⁵, M.D. Baker²⁴, S. Baker⁷⁶, E. Banas³⁸, P. Banerjee⁹², Sw. Banerjee¹⁷², D. Banfi²⁹, A. Bangert¹⁴⁹, V. Bansal¹⁶⁸, H.S. Bansil¹⁷, L. Barak¹⁷¹, S.P. Baranov⁹³, A. Barbaro Galtieri¹⁴, T. Barber⁴⁷, E.L. Barberio⁸⁵, D. Barberis^{49a,49b}, M. Barbero²⁰, D.Y. Bardin⁶³, T. Barillari⁹⁸, M. Barisonzi¹⁷⁴, T. Barklow¹⁴², N. Barlow²⁷, B.M. Barnett¹²⁸, R.M. Barnett¹⁴, A. Baronecelli^{133a}, G. Barone⁴⁸, A.J. Barr¹¹⁷, F. Barreiro⁷⁹, J. Barreiro Guimarães da Costa⁵⁶, P. Barrillon¹¹⁴, R. Bartoldus¹⁴², A.E. Barton⁷⁰, V. Bartsch¹⁴⁸, R.L. Bates⁵², L. Batkova^{143a}, J.R. Batley²⁷, A. Battaglia¹⁶, M. Battistin²⁹, F. Bauer¹³⁵, H.S. Bawa^{142,e}, S. Beale⁹⁷, T. Beau⁷⁷, P.H. Beauchemin¹⁶⁰, R. Beccherle^{49a}, P. Bechtel²⁰, H.P. Beck¹⁶, A.K. Becker¹⁷⁴, S. Becker⁹⁷, M. Beckingham¹³⁷, K.H. Becks¹⁷⁴, A.J. Beddall^{18c}, A. Beddall^{18c}, S. Bedikian¹⁷⁵, V.A. Bednyakov⁶³, C.P. Bee⁸², L.J. Beemster¹⁰⁴, M. Begel²⁴, S. Behar Harpaz¹⁵¹, P.K. Behera⁶¹, M. Beimforde⁹⁸, C. Belanger-Champagne⁸⁴, P.J. Bell⁴⁸, W.H. Bell⁴⁸, G. Bella¹⁵², L. Belagamba^{19a}, F. Bellina²⁹, M. Bellomo²⁹, A. Belloni⁵⁶, O. Beloborodova^{106,f}, K. Belotskiy⁹⁵, O. Beltramello²⁹, O. Benary¹⁵², D. Benchevkroun^{134a}, K. Bendtz^{145a,145b}, N. Benekos¹⁶⁴, Y. Benhammou¹⁵², E. Benhar Noccioli⁴⁸, J.A. Benitez Garcia^{158b}, D.P. Benjamin⁴⁴, M. Benoit¹¹⁴, J.R. Bensinger²², K. Benslama¹²⁹, S. Bentvelsen¹⁰⁴, D. Berge²⁹, E. Bergeaas Kuutmann⁴¹, N. Berger⁴, F. Berghaus¹⁶⁸, E. Berglund¹⁰⁴, J. Beringer¹⁴, P. Bernat⁷⁶, R. Bernhard⁴⁷, C. Bernius²⁴, T. Berry⁷⁵, C. Bertella⁸², A. Bertin^{19a,19b}, F. Bertolucci^{121a,121b}, M.I. Besana^{88a,88b}, G.J. Besjes¹⁰³, N. Besson¹³⁵, S. Bethke⁹⁸, W. Bhimji⁴⁵, R.M. Bianchi²⁹, M. Bianco^{71a,71b}, O. Biebel⁹⁷, S.P. Bieniek⁷⁶, K. Bierwagen⁵³, J. Biesiada¹⁴, M. Biglietti^{133a}, H. Bilokon⁴⁶, M. Bindi^{19a,19b}, S. Binet¹¹⁴, A. Bingul^{18c}, C. Bini^{131a,131b}, C. Biscarat¹⁷⁷, U. Bitenc⁴⁷, K.M. Black²¹, R.E. Blair⁵, J.-B. Blanchard¹³⁵, G. Blanchot²⁹, T. Blazek^{143a}, C. Blocker²², J. Blocki³⁸, A. Blondel⁴⁸, W. Blum⁸⁰, U. Blumenschein⁵³, G.J. Bobbink¹⁰⁴, V.B. Bobrovnikov¹⁰⁶, S.S. Bocchetta⁷⁸, A. Bocchi⁴⁴, C.R. Boddy¹¹⁷, M. Boehler⁴⁷, J. Boek¹⁷⁴, N. Boelaert³⁵, J.A. Bogaerts²⁹, A. Bogdanchikov¹⁰⁶, A. Bogouch^{89,*}, C. Bohm^{145a}, J. Bohm¹²⁴, V. Boisvert⁷⁵, T. Bold³⁷, V. Boldea^{25a}, N.M. Bolnet¹³⁵, M. Bomben⁷⁷, M. Bona⁷⁴, M. Boonekamp¹³⁵, C.N. Booth¹³⁸, S. Bordini⁷⁷, C. Borer¹⁶, A. Borisov¹²⁷, G. Borisso⁷⁰, I. Borjanovic^{12a}, M. Borri⁸¹, S. Borroni⁸⁶, V. Bortolotto^{133a,133b}, K. Bos¹⁰⁴, D. Boscherini^{19a}, M. Bosman¹¹, H. Boterenbrood¹⁰⁴, J. Bouchami⁹², J. Boudreau¹²², E.V. Bouhova-Thacker⁷⁰, D. Boumediene³³, C. Bourdarios¹¹⁴, N. Bousson⁸², A. Boveia³⁰, J. Boyd²⁹, I.R. Boyko⁶³, I. Bozovic-Jelisavcic^{12b}, J. Bracinik¹⁷, P. Branchini^{133a}, G.W. Brandenburg⁵⁶, A. Brandt⁷, G. Brandt¹¹⁷, O. Brandt⁵³, U. Bratzler¹⁵⁵, B. Brau⁸³, J.E. Brau¹¹³, H.M. Braun^{174,*}, S.F. Brazzale^{163a,163c}, B. Brelvi¹⁵⁷, J. Bremer²⁹, K. Brendlinger¹¹⁹, R. Brenner¹⁶⁵, S. Bressler¹⁷¹, D. Britton⁵², F.M. Brochu²⁷, I. Brock²⁰, R. Brock⁸⁷, F. Broggi^{88a}, C. Bromberg⁸⁷, J. Bronner⁹⁸, G. Brooijmans³⁴, T. Brooks⁷⁵, W.K. Brooks^{31b}, G. Brown⁸¹, H. Brown⁷, P.A. Bruckman de Renstrom³⁸, D. Bruncko^{143b}, R. Bruneliere⁴⁷, S. Brunet⁵⁹, A. Bruni^{19a}, G. Bruni^{19a}, M. Bruschi^{19a}, T. Buanes¹³, Q. Buat⁵⁴, F. Bucci⁴⁸, J. Buchanan¹¹⁷, P. Buchholz¹⁴⁰, R.M. Buckingham¹¹⁷, A.G. Buckley⁴⁵, S.I. Buda^{25a}, I.A. Budagov⁶³, B. Budick¹⁰⁷, V. Büscher⁸⁰, L. Bugge¹¹⁶, O. Bulekov⁹⁵, A.C. Bundock⁷², M. Bunse⁴², T. Buran¹¹⁶, H. Burckhart²⁹, S. Burdin⁷², T. Burgess¹³, S. Burke¹²⁸, E. Busato³³, P. Bussey⁵², C.P. Buszello¹⁶⁵, B. Butler¹⁴², J.M. Butler²¹, C.M. Buttar⁵², J.M. Butterworth⁷⁶, W. Buttinger²⁷, S. Cabrera Urbán¹⁶⁶, D. Caforio^{19a,19b}, O. Cakir^{3a}, P. Calafiura¹⁴, G. Calderini⁷⁷, P. Calfayan⁹⁷, R. Calkins¹⁰⁵, L.P. Caloba^{23a}, R. Caloi^{131a,131b}, D. Calvet³³, S. Calvet³³, R. Camacho Toro³³, P. Camarri^{132a,132b}, D. Cameron¹¹⁶, L.M. Caminada¹⁴, S. Campana²⁹, M. Campanelli⁷⁶, V. Canale^{101a,101b}, F. Canelli^{30,g}, A. Canepa^{158a}, J. Cantero⁷⁹, R. Cantrill⁷⁵, L. Capasso^{101a,101b}, M.D.M. Capeans Garrido²⁹, I. Caprini^{25a},

M. Caprini^{25a}, D. Capriotti⁹⁸, M. Capua^{36a,36b}, R. Caputo⁸⁰, R. Cardarelli^{132a}, T. Carli²⁹, G. Carlino^{101a}, L. Carmi-nati^{88a,88b}, B. Caron⁸⁴, S. Caron¹⁰³, E. Carquin^{31b}, G.D. Carrillo Montoya¹⁷², A.A. Carter⁷⁴, J.R. Carter²⁷, J. Carvalho^{123a,h}, D. Casadei¹⁰⁷, M.P. Casado¹¹, M. Cascella^{121a,121b}, C. Caso^{49a,49b,*}, A.M. Castaneda Hernandez^{172,i}, E. Castaneda-Miranda¹⁷², V. Castillo Gimenez¹⁶⁶, N.F. Castro^{123a}, G. Cataldi^{71a}, P. Catastini⁵⁶, A. Catinaccio²⁹, J.R. Catmore²⁹, A. Cat-tai²⁹, G. Cattani^{132a,132b}, S. Caughron⁸⁷, P. Cavalleri⁷⁷, D. Cavalli^{88a}, M. Cavalli-Sforza¹¹, V. Cavasinni^{121a,121b}, F. Cera-dini^{133a,133b}, A.S. Cerqueira^{23b}, A. Cerri²⁹, L. Cerrito⁷⁴, F. Cerutti⁴⁶, S.A. Cetin^{18b}, A. Chafaq^{134a}, D. Chakraborty¹⁰⁵, I. Chalupkova¹²⁵, K. Chan², B. Chapleau⁸⁴, J.D. Chapman²⁷, J.W. Chapman⁸⁶, E. Chareyre⁷⁷, D.G. Charlton¹⁷, V. Chavda⁸¹, C.A. Chavez Barajas²⁹, S. Cheatham⁸⁴, S. Chekanov⁵, S.V. Chekulaev^{158a}, G.A. Chelkov⁶³, M.A. Chelstowska¹⁰³, C. Chen⁶², H. Chen²⁴, S. Chen^{32c}, X. Chen¹⁷², Y. Chen³⁴, A. Cheplakov⁶³, R. Cherkaoui El Moursli^{134e}, V. Cherny-atin²⁴, E. Cheu⁶, S.L. Cheung¹⁵⁷, L. Chevalier¹³⁵, G. Chiefari^{101a,101b}, L. Chikovani^{50a,*}, J.T. Childers²⁹, A. Chilingarov⁷⁰, G. Chiodini^{71a}, A.S. Chisholm¹⁷, R.T. Chislett⁷⁶, A. Chitan^{25a}, M.V. Chizhov⁶³, G. Choudalakis³⁰, S. Chouridou¹³⁶, I.A. Christidi⁷⁶, A. Christov⁴⁷, D. Chromek-Burckhart²⁹, M.L. Chu¹⁵⁰, J. Chudoba¹²⁴, G. Ciapetti^{131a,131b}, A.K. Ciftci^{3a}, R. Ciftci^{3a}, D. Cinca³³, V. Cindro⁷³, C. Ciocca^{19a,19b}, A. Ciochio¹⁴, M. Cirilli⁸⁶, P. Cirkovic^{12b}, M. Citterio^{88a}, M. Ciuban-can^{25a}, A. Clark⁴⁸, P.J. Clark⁴⁵, R.N. Clarke¹⁴, W. Cleland¹²², J.C. Clemens⁸², B. Clement⁵⁴, C. Clement^{145a,145b}, Y. Coadou⁸², M. Cobal^{163a,163c}, A. Cocco¹³⁷, J. Cochran⁶², J.G. Cogan¹⁴², J. Coggeshall¹⁶⁴, E. Cogneras¹⁷⁷, J. Col-las⁴, S. Cole¹⁰⁵, A.P. Colijn¹⁰⁴, N.J. Collins¹⁷, C. Collins-Tooth⁵², J. Collot⁵⁴, T. Colombo^{118a,118b}, G. Colon⁸³, P. Conde Muiño^{123a}, E. Coniavitis¹¹⁷, M.C. Conidi¹¹, S.M. Consonni^{88a,88b}, V. Consorti⁴⁷, S. Constantinescu^{25a}, C. Conta^{118a,118b}, G. Conti⁵⁶, F. Conventi^{101a,j}, M. Cooke¹⁴, B.D. Cooper⁷⁶, A.M. Cooper-Sarkar¹¹⁷, K. Copic¹⁴, T. Cornelissen¹⁷⁴, M. Cor-radi^{19a}, F. Corriveau^{84,k}, A. Cortes-Gonzalez¹⁶⁴, G. Cortiana⁹⁸, G. Costa^{88a}, M.J. Costa¹⁶⁶, D. Costanzo¹³⁸, T. Costin³⁰, D. Côté²⁹, L. Courneyea¹⁶⁸, G. Cowan⁷⁵, C. Cowden²⁷, B.E. Cox⁸¹, K. Cranmer¹⁰⁷, F. Crescioli^{121a,121b}, M. Cristinziani²⁰, G. Crosetti^{36a,36b}, S. Crépe-Renaudin⁵⁴, C.-M. Cuciuc^{25a}, C. Cuenca Almenar¹⁷⁵, T. Cuhadar Donszelmann¹³⁸, M. Cu-ratolo⁴⁶, C.J. Curtis¹⁷, C. Cuthbert¹⁴⁹, P. Cwetanski⁵⁹, H. Czirr¹⁴⁰, P. Czodrowski⁴³, Z. Czyzula¹⁷⁵, S. D'Auria⁵², M. D'Onofrio⁷², A. D'Orazio^{131a,131b}, M.J. Da Cunha Sargedass De Sousa^{123a}, C. Da Via⁸¹, W. Dabrowski³⁷, A. Dafinca¹¹⁷, T. Dai⁸⁶, C. Dallapiccola⁸³, M. Dam³⁵, M. Dameri^{49a,49b}, D.S. Damiani¹³⁶, H.O. Danielsson²⁹, V. Dao⁴⁸, G. Darbo^{49a}, G.L. Darlea^{25b}, J.A. Dassoulas⁴¹, W. Davey²⁰, T. Davidek¹²⁵, N. Davidson⁸⁵, R. Davidson⁷⁰, E. Davies^{117,c}, M. Davies⁹², O. Davignon⁷⁷, A.R. Davison⁷⁶, Y. Davygora^{57a}, E. Dawe¹⁴¹, I. Dawson¹³⁸, R.K. Daya-Ishmukhametova²², K. De⁷, R. de Asmundis^{101a}, S. De Castro^{19a,19b}, S. De Cecco⁷⁷, J. de Graat⁹⁷, N. De Groot¹⁰³, P. de Jong¹⁰⁴, C. De La Taille¹¹⁴, H. De la Torre⁷⁹, F. De Lorenzi⁶², L. de Mora⁷⁰, L. De Nooij¹⁰⁴, D. De Pedis^{131a}, A. De Salvo^{131a}, U. De Sanc-tis^{163a,163c}, A. De Santo¹⁴⁸, J.B. De Vivie De Regie¹¹⁴, G. De Zorzi^{131a,131b}, W.J. Dearnaley⁷⁰, R. Debbé²⁴, C. Debenedetti⁴⁵, B. Dechenaux⁵⁴, D.V. Dedovich⁶³, J. Degenhardt¹¹⁹, C. Del Papa^{163a,163c}, J. Del Peso⁷⁹, T. Del Prete^{121a,121b}, T. Dele-montex⁵⁴, M. Deliyergiyev⁷³, A. Dell'Acqua²⁹, L. Dell'Asta²¹, M. Della Pietra^{101a,j}, D. della Volpe^{101a,101b}, M. Del-mastro⁴, P.A. Delsart⁵⁴, C. Deluca¹⁰⁴, S. Demers¹⁷⁵, M. Demichev⁶³, B. Demirköz^{11,i}, J. Deng¹⁶², S.P. Denisov¹²⁷, D. Derendarz³⁸, J.E. Derkaoui^{134d}, F. Derue⁷⁷, P. Dervan⁷², K. Desch²⁰, E. Devetak¹⁴⁷, P.O. Deviveiros¹⁰⁴, A. Dewhurst¹²⁸, B. DeWilde¹⁴⁷, S. Dhalwal¹⁵⁷, R. Dhullipudi^{24,m}, A. Di Ciccio^{132a,132b}, L. Di Ciccio⁴, A. Di Girolamo²⁹, B. Di Giro-lamo²⁹, S. Di Luise^{133a,133b}, A. Di Mattia¹⁷², B. Di Micco²⁹, R. Di Nardo⁴⁶, A. Di Simone^{132a,132b}, R. Di Sipio^{19a,19b}, M.A. Diaz^{31a}, E.B. Diehl⁸⁶, J. Dietrich⁴¹, T.A. Dietzsch^{57a}, S. Diglio⁸⁵, K. Dindar Yagci³⁹, J. Dingfelder²⁰, F. Dinut^{25a}, C. Dionisi^{131a,131b}, P. Dita^{25a}, S. Dita^{25a}, F. Dittus²⁹, F. Djama⁸², T. Djobava^{50b}, M.A.B. do Vale^{23c}, A. Do Valle We-mans^{123a,n}, T.K.O. Doan⁴, M. Dobbs⁸⁴, R. Dobinson^{29,*}, D. Dobos²⁹, E. Dobson^{29,o}, J. Dodd³⁴, C. Doglioni⁴⁸, T. Doherty⁵², Y. Doi^{64,*}, J. Dolejsi¹²⁵, I. Dolenc⁷³, Z. Dolezal¹²⁵, B.A. Dolgoshein^{95,*}, T. Dohmae¹⁵⁴, M. Donadelli^{23d}, J. Donini³³, J. Dopke²⁹, A. Doria^{101a}, A. Dos Anjos¹⁷², A. Dotti^{121a,121b}, M.T. Dova⁶⁹, A.D. Doxiadis¹⁰⁴, A.T. Doyle⁵², N. Dress-nandt¹¹⁹, M. Dris⁹, J. Dubbert⁹⁸, S. Dube¹⁴, E. Duchovni¹⁷¹, G. Duckeck⁹⁷, A. Dudarev²⁹, F. Dudziak⁶², M. Dührssen²⁹, I.P. Duerdoth⁸¹, L. Duflot¹¹⁴, M.-A. Dufour⁸⁴, L. Duguid⁷⁵, M. Dunford²⁹, H. Duran Yildiz^{3a}, R. Duxfield¹³⁸, M. Dwuznik³⁷, F. Dydak²⁹, M. Düren⁵¹, W.L. Ebenstein⁴⁴, J. Ebke⁹⁷, S. Eckweiler⁸⁰, K. Edmonds⁸⁰, W. Edson¹, C.A. Edwards⁷⁵, N.C. Ed-wards⁵², W. Ehrenfeld⁴¹, T. Eifert¹⁴², G. Eigen¹³, K. Einsweiler¹⁴, E. Eisenhandler⁷⁴, T. Ekelof¹⁶⁵, M. El Kacimi^{134c}, M. Ellert¹⁶⁵, S. Elles⁴, F. Ellinghaus⁸⁰, K. Ellis⁷⁴, N. Ellis²⁹, J. Elmsheuser⁹⁷, M. Elsing²⁹, D. Emelianov¹²⁸, R. En-gelmann¹⁴⁷, A. Engl⁹⁷, B. Epp⁶⁰, J. Erdmann⁵³, A. Ereditato¹⁶, D. Eriksson^{145a}, J. Ernst¹, M. Ernst²⁴, J. Ernwein¹³⁵, D. Errede¹⁶⁴, S. Errede¹⁶⁴, E. Ertel⁸⁰, M. Escalier¹¹⁴, H. Esch⁴², C. Escobar¹²², X. Espinal Curull¹¹, B. Esposito⁴⁶, F. Etienne⁸², A.I. Etievre¹³⁵, E. Etzion¹⁵², D. Evangelakou⁵³, H. Evans⁵⁹, L. Fabbri^{19a,19b}, C. Fabre²⁹, R.M. Fakhruddi-nov¹²⁷, S. Falciano^{131a}, Y. Fang¹⁷², M. Fanti^{88a,88b}, A. Farbin⁷, A. Farilla^{133a}, J. Farley¹⁴⁷, T. Farooque¹⁵⁷, S. Farrell¹⁶², S.M. Farrington¹⁶⁹, P. Farthouat²⁹, P. Fassnacht²⁹, D. Fassouliotis⁸, B. Fatholahzadeh¹⁵⁷, A. Favareto^{88a,88b}, L. Fayard¹¹⁴, S. Fazio^{36a,36b}, R. Febbraro³³, P. Federic^{143a}, O.L. Fedin¹²⁰, W. Fedorko⁸⁷, M. Fehling-Kaschek⁴⁷, L. Feligioni⁸², D. Fell-mann⁵, C. Feng^{32d}, E.J. Feng⁵, A.B. Fenyuk¹²⁷, J. Ferencei^{143b}, W. Fernando⁵, S. Ferrag⁵², J. Ferrando⁵², V. Ferrara⁴¹, A. Ferrari¹⁶⁵, P. Ferrari¹⁰⁴, R. Ferrari^{118a}, D.E. Ferreira de Lima⁵², A. Ferrer¹⁶⁶, D. Ferrere⁴⁸, C. Ferretti⁸⁶, A. Fer-retto Parodi^{49a,49b}, M. Fiascaris³⁰, F. Fiedler⁸⁰, A. Filipčič⁷³, F. Filthaut¹⁰³, M. Fincke-Keeler¹⁶⁸, M.C.N. Fiolhais^{123a,h}

L. Fiorini¹⁶⁶, A. Firan³⁹, G. Fischer⁴¹, M.J. Fisher¹⁰⁸, M. Flechl⁴⁷, I. Fleck¹⁴⁰, J. Fleckner⁸⁰, P. Fleischmann¹⁷³, S. Fleischmann¹⁷⁴, T. Flick¹⁷⁴, A. Floderus⁷⁸, L.R. Flores Castillo¹⁷², M.J. Flowerdew⁹⁸, T. Fonseca Martin¹⁶, A. Formica¹³⁵, A. Forti⁸¹, D. Fortin^{158a}, D. Fournier¹¹⁴, A.J. Fowler⁴⁴, H. Fox⁷⁰, P. Francavilla¹¹, M. Franchini^{19a,19b}, S. Franchino^{118a,118b}, D. Francis²⁹, T. Frank¹⁷¹, S. Franz²⁹, M. Fraternali^{118a,118b}, S. Fratina¹¹⁹, S.T. French²⁷, C. Friedrich⁴¹, F. Friedrich⁴³, R. Froeschl²⁹, D. Froidevaux²⁹, J.A. Frost²⁷, C. Fukunaga¹⁵⁵, E. Fullana Torregrosa²⁹, B.G. Fulsom¹⁴², J. Fuster¹⁶⁶, C. Gabaldon²⁹, O. Gabizon¹⁷¹, T. Gadfort²⁴, S. Gadomski⁴⁸, G. Gagliardi^{49a,49b}, P. Gagnon⁵⁹, C. Galea⁹⁷, E.J. Galas¹¹⁷, V. Gallo¹⁶, B.J. Gallop¹²⁸, P. Gallus¹²⁴, K.K. Gan¹⁰⁸, Y.S. Gao^{142,e}, A. Gaponenko¹⁴, F. Garbersen¹⁷⁵, M. Garcia-Sciveres¹⁴, C. García¹⁶⁶, J.E. García Navarro¹⁶⁶, R.W. Gardner³⁰, N. Garelli²⁹, H. Garitaonandia¹⁰⁴, V. Garonne²⁹, J. Garvey¹⁷, C. Gatti⁴⁶, G. Gaudio^{118a}, B. Gaur¹⁴⁰, L. Gauthier¹³⁵, P. Gauzzi^{131a,131b}, I.L. Gavrilenko⁹³, C. Gay¹⁶⁷, G. Gaycken²⁰, E.N. Gaziz⁹, P. Ge^{32d}, Z. Gecse¹⁶⁷, C.N.P. Gee¹²⁸, D.A.A. Geerts¹⁰⁴, Ch. Geich-Gimbel²⁰, K. Gellerstedt^{145a,145b}, C. Gemme^{49a}, A. Gemmell⁵², M.H. Genest⁵⁴, S. Gentile^{131a,131b}, M. George⁵³, S. George⁷⁵, P. Gerlach¹⁷⁴, A. Gershon¹⁵², C. Geweniger^{57a}, H. Ghazlane^{134b}, N. Ghodbane³³, B. Giacobbe^{19a}, S. Giagu^{131a,131b}, V. Giakoumopoulou⁸, V. Giangiobbe¹¹, F. Gianotti²⁹, B. Gibbard²⁴, A. Gibson¹⁵⁷, S.M. Gibson²⁹, D. Gillberg²⁸, A.R. Gillman¹²⁸, D.M. Gingrich^{2,d}, J. Ginzburg¹⁵², N. Giokaris⁸, M.P. Giordani^{163c}, R. Giordano^{101a,101b}, F.M. Giorgi¹⁵, P. Giovannini⁹⁸, P.F. Giraud¹³⁵, D. Giugni^{88a}, M. Giunta⁹², P. Giusti^{19a}, B.K. Gjelsten¹¹⁶, L.K. Gladilin⁹⁶, C. Glasman⁷⁹, J. Glatzer⁴⁷, A. Glazov⁴¹, K.W. Glitza¹⁷⁴, G.L. Glonti⁶³, J.R. Goddard⁷⁴, J. Godfrey¹⁴¹, J. Godlewski²⁹, M. Goebel⁴¹, T. Göpfert⁴³, C. Goeringer⁸⁰, C. Gössling⁴², S. Goldfarb⁸⁶, T. Golling¹⁷⁵, A. Gomes^{123a,b}, L.S. Gomez Fajardo⁴¹, R. Gonçalves⁷⁵, J. Goncalves Pinto Firmino Da Costa⁴¹, L. Gonella²⁰, S. Gonzalez¹⁷², S. González de la Hoz¹⁶⁶, G. Gonzalez Parra¹¹, M.L. Gonzalez Silva²⁶, S. Gonzalez-Sevilla⁴⁸, J.J. Goodson¹⁴⁷, L. Goossens²⁹, P.A. Gorbounov⁹⁴, H.A. Gordon²⁴, I. Gorelov¹⁰², G. Gorfine¹⁷⁴, B. Gorini²⁹, E. Gorini^{71a,71b}, A. Gorišek⁷³, E. Gornicki³⁸, B. Gosdzik⁴¹, A.T. Goshaw⁵, M. Gosselink¹⁰⁴, M.I. Gostkin⁶³, I. Gough Eschrich¹⁶², M. Gouighri^{134a}, D. Goujdami^{134c}, M.P. Goulette⁴⁸, A.G. Goussiou¹³⁷, C. Goy⁴, S. Gozpinar²², I. Grabowska-Bold³⁷, P. Grafström^{19a,19b}, K.-J. Grahn⁴¹, F. Grancagnolo^{71a}, S. Grancagnolo¹⁵, V. Grassi¹⁴⁷, V. Gratchev¹²⁰, N. Grau³⁴, H.M. Gray²⁹, J.A. Gray¹⁴⁷, E. Graziani^{133a}, O.G. Grebenyuk¹²⁰, T. Greenshaw⁷², Z.D. Greenwood^{24,m}, K. Gregersen³⁵, I.M. Gregor⁴¹, P. Grenier¹⁴², J. Griffiths¹³⁷, N. Grigalashvili⁶³, A.A. Grillo¹³⁶, S. Grinstein¹¹, Y.V. Grishkevich⁹⁶, J.-F. Grivaz¹¹⁴, E. Gross¹⁷¹, J. Grosse-Knetter⁵³, J. Groth-Jensen¹⁷¹, K. Grybel¹⁴⁰, D. Guest¹⁷⁵, C. Guicheney³³, S. Guindon⁵³, U. Gul⁵², H. Guler^{84,p}, J. Gunther¹²⁴, B. Guo¹⁵⁷, J. Guo³⁴, P. Gutierrez¹¹⁰, N. Guttman¹⁵², O. Gutzwiller¹⁷², C. Guyot¹³⁵, C. Gwenlan¹¹⁷, C.B. Gwilliam⁷², A. Haas¹⁴², S. Haas²⁹, C. Haber¹⁴, H.K. Hadavand³⁹, D.R. Hadley¹⁷, P. Haefner²⁰, F. Hahn²⁹, S. Haider²⁹, Z. Hajduk³⁸, H. Hakobyan¹⁷⁶, D. Hall¹¹⁷, J. Haller⁵³, K. Hamacher¹⁷⁴, P. Hamal¹¹², M. Hamer⁵³, A. Hamilton^{144b,q}, S. Hamilton¹⁶⁰, L. Han^{32b}, K. Hanagaki¹¹⁵, K. Hanawa¹⁵⁹, M. Hance¹⁴, C. Handel⁸⁰, P. Hanke^{57a}, J.R. Hansen³⁵, J.B. Hansen³⁵, J.D. Hansen³⁵, P.H. Hansen³⁵, P. Hansson¹⁴², K. Hara¹⁵⁹, G.A. Hare¹³⁶, T. Harenberg¹⁷⁴, S. Harkusha⁸⁹, D. Harper⁸⁶, R.D. Harrington⁴⁵, O.M. Harris¹³⁷, J. Hartert⁴⁷, F. Hartjes¹⁰⁴, T. Haruyama⁶⁴, A. Harvey⁵⁵, S. Hasegawa¹⁰⁰, Y. Hasegawa¹³⁹, S. Hassani¹³⁵, S. Haug¹⁶, M. Hauschild²⁹, R. Hauser⁸⁷, M. Havranek²⁰, C.M. Hawkes¹⁷, R.J. Hawkins²⁹, A.D. Hawkins⁷⁸, D. Hawkins¹⁶², T. Hayakawa⁶⁵, T. Hayashi¹⁵⁹, D. Hayden⁷⁵, C.P. Hays¹¹⁷, H.S. Hayward⁷², S.J. Haywood¹²⁸, M. He^{32d}, S.J. Head¹⁷, V. Hedberg⁷⁸, L. Heelan⁷, S. Heim⁸⁷, B. Heinemann¹⁴, S. Heisterkamp³⁵, L. Helary²¹, C. Heller⁹⁷, M. Heller²⁹, S. Hellman^{145a,145b}, D. Hellmich²⁰, C. Helsens¹¹, R.C.W. Henderson⁷⁰, M. Henke^{57a}, A. Henrichs⁵³, A.M. Henriques Correia²⁹, S. Henrot-Versille¹¹⁴, C. Hensel⁵³, T. Henß¹⁷⁴, C.M. Hernandez⁷, Y. Hernández Jiménez¹⁶⁶, R. Herrberg¹⁵, G. Herten⁴⁷, R. Hertenberger⁹⁷, L. Hervas²⁹, G.G. Hesketh⁷⁶, N.P. Hessey¹⁰⁴, E. Higón-Rodríguez¹⁶⁶, J.C. Hill²⁷, K.H. Hiller⁴¹, S. Hillert²⁰, S.J. Hillier¹⁷, I. Hinchliffe¹⁴, E. Hines¹¹⁹, M. Hirose¹¹⁵, F. Hirsch⁴², D. Hirschbuehl¹⁷⁴, J. Hobbs¹⁴⁷, N. Hod¹⁵², M.C. Hodgkinson¹³⁸, P. Hodgson¹³⁸, A. Hoecker²⁹, M.R. Hoferkamp¹⁰², J. Hoffman³⁹, D. Hoffmann⁸², M. Hohlfield⁸⁰, M. Holder¹⁴⁰, S.O. Holmgren^{145a}, T. Holy¹²⁶, J.L. Holzbauer⁸⁷, T.M. Hong¹¹⁹, L. Hooft van Huysduynen¹⁰⁷, C. Horn¹⁴², S. Horner⁴⁷, J.-Y. Hostachy⁵⁴, S. Hou¹⁵⁰, A. Hoummada^{134a}, J. Howard¹¹⁷, J. Howarth⁸¹, I. Hristova¹⁵, J. Hrivnac¹¹⁴, T. Hryn'ova⁴, P.J. Hsu⁸⁰, S.-C. Hsu¹⁴, Z. Hubacek¹²⁶, F. Hubaut⁸², F. Huegging²⁰, A. Huettmann⁴¹, T.B. Huffman¹¹⁷, E.W. Hughes³⁴, G. Hughes⁷⁰, M. Huhtinen²⁹, M. Hurwitz¹⁴, U. Husemann⁴¹, N. Huseynov^{63,r}, J. Huston⁸⁷, J. Huth⁵⁶, G. Iacobucci⁴⁸, G. Iakovidis⁹, M. Ibbotson⁸¹, I. Ibragimov¹⁴⁰, L. Iconomidou-Fayard¹¹⁴, J. Idarraga¹¹⁴, P. Iengo^{101a}, O. Igonkina¹⁰⁴, Y. Ikegami⁶⁴, M. Ikeno⁶⁴, D. Iliadis¹⁵³, N. Ilic¹⁵⁷, T. Ince²⁰, J. Inigo-Golfín²⁹, P. Ioannou⁸, M. Iodice^{133a}, K. Iordanidou⁸, V. Ippolito^{131a,131b}, A. Irls Quiles¹⁶⁶, C. Isaksson¹⁶⁵, M. Ishino⁶⁶, M. Ishitsuka¹⁵⁶, R. Ishmukhametov³⁹, C. Issever¹¹⁷, S. Istin^{18a}, A.V. Ivashin¹²⁷, W. Iwanski³⁸, H. Iwasaki⁶⁴, J.M. Izen⁴⁰, V. Izzo^{101a}, B. Jackson¹¹⁹, J.N. Jackson⁷², P. Jackson¹⁴², M.R. Jaekel²⁹, V. Jain⁵⁹, K. Jakobs⁴⁷, S. Jakobsen³⁵, T. Jakoubek¹²⁴, J. Jakubek¹²⁶, D.K. Jana¹¹⁰, E. Jansen⁷⁶, H. Jansen²⁹, A. Jantsch⁹⁸, M. Janus⁴⁷, G. Jarlskog⁷⁸, L. Jeanty⁵⁶, I. Jen-La Plante³⁰, D. Jennens⁸⁵, P. Jenni²⁹, P. Jez³⁵, S. Jézéquel⁴, M.K. Jha^{19a}, H. Ji¹⁷², W. Ji⁸⁰, J. Jia¹⁴⁷, Y. Jiang^{32b}, M. Jimenez Belenguer⁴¹, S. Jin^{32a}, O. Jinnouchi¹⁵⁶, M.D. Joergensen³⁵, D. Joffe³⁹, M. Johansen^{145a,145b}, K.E. Johansson^{145a}, P. Johansson¹³⁸, S. Johnert⁴¹, K.A. Johns⁶, K. Jon-And^{145a,145b}, G. Jones¹⁶⁹, R.W.L. Jones⁷⁰, T.J. Jones⁷², C. Joram²⁹, P.M. Jorge^{123a},

K.D. Joshi⁸¹, J. Jovicevic¹⁴⁶, T. Jovin^{12b}, X. Ju¹⁷², C.A. Jung⁴², R.M. Jungst²⁹, V. Juranek¹²⁴, P. Jussel⁶⁰, A. Juste Rozas¹¹, S. Kabana¹⁶, M. Kaci¹⁶⁶, A. Kaczmarzka³⁸, P. Kadlecik³⁵, M. Kado¹¹⁴, H. Kagan¹⁰⁸, M. Kagan⁵⁶, E. Kajomovitz¹⁵¹, S. Kalinin¹⁷⁴, L.V. Kalinovskaya⁶³, S. Kama³⁹, N. Kanaya¹⁵⁴, M. Kaneda²⁹, S. Kaneti²⁷, T. Kanno¹⁵⁶, V.A. Kantserov⁹⁵, J. Kanzaki⁶⁴, B. Kaplan¹⁷⁵, A. Kapliy³⁰, J. Kaplon²⁹, D. Kar⁵², M. Karagounis²⁰, K. Karakostas⁹, M. Karneviskiy⁴¹, V. Kartvelishvili⁷⁰, A.N. Karyukhin¹²⁷, L. Kashif¹⁷², G. Kasieczka^{57b}, R.D. Kass¹⁰⁸, A. Kastanas¹³, M. Kataoka⁴, Y. Kataoka¹⁵⁴, E. Katsoufis⁹, J. Katzy⁴¹, V. Kaushik⁶, K. Kawagoe⁶⁸, T. Kawamoto¹⁵⁴, G. Kawamura⁸⁰, M.S. Kayl¹⁰⁴, V.A. Kazanin¹⁰⁶, M.Y. Kazarinov⁶³, R. Keeler¹⁶⁸, P.T. Keener¹¹⁹, R. Kehoe³⁹, M. Keil⁵³, G.D. Kekelidze⁶³, J.S. Keller¹³⁷, M. Kenyon⁵², O. Kepka¹²⁴, N. Kerschen²⁹, B.P. Kerševan⁷³, S. Kersten¹⁷⁴, K. Kessoku¹⁵⁴, J. Keung¹⁵⁷, F. Khalil-zada¹⁰, H. Khandanyan¹⁶⁴, A. Khanov¹¹¹, D. Kharchenko⁶³, A. Khodinov⁹⁵, A. Khomich^{57a}, T.J. Khoo²⁷, G. Khoriauli²⁰, A. Khoroshilov¹⁷⁴, V. Khovanskiy⁹⁴, E. Khramov⁶³, J. Khubua^{50b}, H. Kim^{145a,145b}, S.H. Kim¹⁵⁹, N. Kimura¹⁷⁰, O. Kind¹⁵, B.T. King⁷², M. King⁶⁵, R.S.B. King¹¹⁷, J. Kirk¹²⁸, A.E. Kiryunin⁹⁸, T. Kishimoto⁶⁵, D. Kisieleska³⁷, T. Kitamura⁶⁵, T. Kittelmann¹²², E. Kladiva^{143b}, M. Klein⁷², U. Klein⁷², K. Kleinknecht⁸⁰, M. Klemetti⁸⁴, A. Klier¹⁷¹, P. Klimek^{145a,145b}, A. Klimentov²⁴, R. Klingenberg⁴², J.A. Klinger⁸¹, E.B. Klinkby³⁵, T. Klioutchnikova²⁹, P.F. Klok¹⁰³, S. Klous¹⁰⁴, E.-E. Kluge^{57a}, T. Kluge⁷², P. Kluit¹⁰⁴, S. Kluth⁹⁸, N.S. Knecht¹⁵⁷, E. Kneringer⁶⁰, E.B.F.G. Knoops⁸², A. Knue⁵³, B.R. Ko⁴⁴, T. Kobayashi¹⁵⁴, M. Kobel⁴³, M. Kocian¹⁴², P. Kodys¹²⁵, K. Köneke²⁹, A.C. König¹⁰³, S. Koenig⁸⁰, L. Köpke⁸⁰, F. Koetsveld¹⁰³, P. Koevesarki²⁰, T. Koffas²⁸, E. Koffeman¹⁰⁴, L.A. Kogan¹¹⁷, S. Kohlmann¹⁷⁴, F. Kohn⁵³, Z. Kohout¹²⁶, T. Kohriki⁶⁴, T. Koi¹⁴², G.M. Kolachev^{106,*}, H. Kolanoski¹⁵, V. Kolesnikov⁶³, I. Koletsou^{88a}, J. Koll⁸⁷, M. Kollefath⁴⁷, A.A. Komar⁹³, Y. Komori¹⁵⁴, T. Kondo⁶⁴, T. Kono^{41,s}, A.I. Kononov⁴⁷, R. Konoplich^{107,t}, N. Konstantinidis⁷⁶, S. Koperny³⁷, K. Korcyl³⁸, K. Kordas¹⁵³, A. Korn¹¹⁷, A. Korol¹⁰⁶, I. Korolkov¹¹, E.V. Korolkova¹³⁸, V.A. Korotkov¹²⁷, O. Kortner⁹⁸, S. Kortner⁹⁸, V.V. Kostyukhin²⁰, S. Kotov⁹⁸, V.M. Kotov⁶³, A. Kotwal⁴⁴, C. Kourkoumelis⁸, V. Kouskoura¹⁵³, A. Koutsman^{158a}, R. Kowalewski¹⁶⁸, T.Z. Kowalski³⁷, W. Kozanecki¹³⁵, A.S. Kozhin¹²⁷, V. Kral¹²⁶, V.A. Kramarenko⁹⁶, G. Kramberger⁷³, M.W. Krasny⁷⁷, A. Krasznahorkay¹⁰⁷, J.K. Kraus²⁰, S. Kreiss¹⁰⁷, F. Krejci¹²⁶, J. Kretzschmar⁷², N. Krieger⁵³, P. Krieger¹⁵⁷, K. Kroeninger⁵³, H. Kroha⁹⁸, J. Kroll¹¹⁹, J. Kroseberg²⁰, J. Krstic^{12a}, U. Kruchonak⁶³, H. Krüger²⁰, T. Kruker¹⁶, N. Krumnack⁶², Z.V. Krumsteyn⁶³, T. Kubota⁸⁵, S. Kudah^{3a}, S. Kuehn⁴⁷, A. Kugel^{57c}, T. Kuhl⁴¹, D. Kuhn⁶⁰, V. Kukhtin⁶³, Y. Kulchitsky⁸⁹, S. Kuleshov^{31b}, C. Kummer⁹⁷, M. Kuna⁷⁷, J. Kunkle¹¹⁹, A. Kupco¹²⁴, H. Kurashige⁶⁵, M. Kurata¹⁵⁹, Y.A. Kurochkin⁸⁹, V. Kus¹²⁴, E.S. Kuwertz¹⁴⁶, M. Kuze¹⁵⁶, J. Kvita¹⁴¹, R. Kwee¹⁵, A. La Rosa⁴⁸, L. La Rotonda^{36a,36b}, L. Labarga⁷⁹, J. Labbe⁴, S. Lablak^{134a}, C. Lacasta¹⁶⁶, F. Lacava^{131a,131b}, H. Lacker¹⁵, D. Lacour⁷⁷, V.R. Lacuesta¹⁶⁶, E. Ladygin⁶³, R. Lafaye⁴, B. Laforge⁷⁷, T. Lagouri⁷⁹, S. Lai⁴⁷, E. Laisne⁵⁴, M. Lamanna²⁹, L. Lambourne⁷⁶, C.L. Lampen⁶, W. Lampl⁶, E. Lancon¹³⁵, U. Landgraf⁴⁷, M.P.J. Landon⁷⁴, J.L. Lane⁸¹, V.S. Lang^{57a}, C. Lange⁴¹, A.J. Lankford¹⁶², F. Lanni²⁴, K. Lantzsche¹⁷⁴, S. Laplace⁷⁷, C. Lapoire²⁰, J.F. Laporte¹³⁵, T. Lari^{88a}, A. Larner¹¹⁷, M. Lassnig²⁹, P. Laurelli⁴⁶, V. Lavorini^{36a,36b}, W. Lavrijsen¹⁴, P. Laycock⁷², O. Le Dortz⁷⁷, E. Le Guirrec⁸², C. Le Maner¹⁵⁷, E. Le Menedeu¹¹, T. LeCompte⁵, F. Ledroit-Guillon⁵⁴, H. Lee¹⁰⁴, J.S.H. Lee¹¹⁵, S.C. Lee¹⁵⁰, L. Lee¹⁷⁵, M. Lefebvre¹⁶⁸, M. Legendre¹³⁵, F. Legger⁹⁷, C. Leggett¹⁴, M. Lehmacher²⁰, G. Lehmann Miotto²⁹, X. Lei⁶, M.A.L. Leite^{23d}, R. Leitner¹²⁵, D. Lellouch¹⁷¹, B. Lemmer⁵³, V. Lendermann^{57a}, K.J.C. Leney^{144b}, T. Lenz¹⁰⁴, G. Lenzen¹⁷⁴, B. Lenzi²⁹, K. Leonhardt⁴³, S. Leontsinis⁹, F. Lepold^{57a}, C. Leroy⁹², J.-R. Lessard¹⁶⁸, C.G. Lester²⁷, C.M. Lester¹¹⁹, J. Levêque⁴, D. Levin⁸⁶, L.J. Levinson¹⁷¹, A. Lewis¹¹⁷, G.H. Lewis¹⁰⁷, A.M. Leyko²⁰, M. Leyton¹⁵, B. Li⁸², H. Li^{172,u}, S. Li^{32b,v}, X. Li⁸⁶, Z. Liang^{117,w}, H. Liao³³, B. Liberti^{132a}, P. Lichard²⁹, M. Lichtnecker⁹⁷, K. Lie¹⁶⁴, W. Liebig¹³, C. Limbach²⁰, A. Limosani⁸⁵, M. Limper⁶¹, S.C. Lin^{150,x}, F. Linde¹⁰⁴, J.T. Linnemann⁸⁷, E. Lipeles¹¹⁹, A. Lipniacka¹³, T.M. Liss¹⁶⁴, D. Lissauer²⁴, A. Lister⁴⁸, A.M. Litke¹³⁶, C. Liu²⁸, D. Liu¹⁵⁰, H. Liu⁸⁶, J.B. Liu⁸⁶, L. Liu⁸⁶, M. Liu^{32b}, Y. Liu^{32b}, M. Livan^{118a,118b}, S.S.A. Livermore¹¹⁷, A. Lleres⁵⁴, J. Llorente Merino⁷⁹, S.L. Lloyd⁷⁴, E. Lobodzinska⁴¹, P. Loch⁶, W.S. Lockman¹³⁶, T. Loddenkoetter²⁰, F.K. Loebinger⁸¹, A. Loginov¹⁷⁵, C.W. Loh¹⁶⁷, T. Lohse¹⁵, K. Lohwasser⁴⁷, M. Lokajicek¹²⁴, V.P. Lombardo⁴, R.E. Long⁷⁰, L. Lopes^{123a}, D. Lopez Mateos⁵⁶, J. Lorenz⁹⁷, N. Lorenzo Martinez¹¹⁴, M. Losada¹⁶¹, P. Loscutoff¹⁴, F. Lo Sterzo^{131a,131b}, M.J. Losty^{158a}, X. Lou⁴⁰, A. Lounis¹¹⁴, K.F. Loureiro¹⁶¹, J. Love²¹, P.A. Love⁷⁰, A.J. Lowe^{142,e}, F. Lu^{32a}, H.J. Lubatti¹³⁷, C. Luci^{131a,131b}, A. Lucotte⁵⁴, A. Ludwig⁴³, D. Ludwig⁴¹, I. Ludwig⁴⁷, J. Ludwig⁴⁷, F. Luehring⁵⁹, G. Luijckx¹⁰⁴, W. Lukas⁶⁰, D. Lumb⁴⁷, L. Luminari^{131a}, E. Lund¹¹⁶, B. Lund-Jensen¹⁴⁶, B. Lundberg⁷⁸, J. Lundberg^{145a,145b}, O. Lundberg^{145a,145b}, J. Lundquist³⁵, M. Lungwitz⁸⁰, D. Lynn²⁴, E. Lytken⁷⁸, H. Ma²⁴, L.L. Ma¹⁷², G. Maccarrone⁴⁶, A. Macchiolo⁹⁸, B. Maček⁷³, J. Machado Miguens^{123a}, R. Mackeprang³⁵, R.J. Madaras¹⁴, H.J. Maddocks⁷⁰, W.F. Mader⁴³, R. Maenner^{57c}, T. Maeno²⁴, P. Mättig¹⁷⁴, S. Mättig⁴¹, L. Magnoni²⁹, E. Magradze⁵³, K. Mahboubi⁴⁷, S. Mahmoud⁷², G. Mahout¹⁷, C. Maiani¹³⁵, C. Maidantchik^{23a}, A. Maio^{123a,b}, S. Majewski²⁴, Y. Makida⁶⁴, N. Makovec¹¹⁴, P. Mal¹³⁵, B. Malaescu²⁹, Pa. Malecki³⁸, P. Malecki³⁸, V.P. Maleev¹²⁰, F. Malek⁵⁴, U. Mallik⁶¹, D. Malon⁵, C. Malone¹⁴², S. Maltezos⁹, V. Malyshev¹⁰⁶, S. Malyukov²⁹, R. Mameghani⁹⁷, J. Mamuzic^{12b}, A. Manabe⁶⁴, L. Mandelli^{88a}, I. Mandić⁷³, R. Mandrysch¹⁵, J. Maneira^{123a}, P.S. Mangeard⁸⁷, L. Manhaes de Andrade Filho^{23b}, J.A. Manjares Ramos¹³⁵, A. Mann⁵³, P.M. Manning¹³⁶, A. Manousakis-Katsikakis⁸, B. Mansoulie¹³⁵, A. Mapelli²⁹, L. Mapelli²⁹,

L. March⁷⁹, J.F. Marchand²⁸, F. Marchese^{132a,132b}, G. Marchiori⁷⁷, M. Marcisovsky¹²⁴, C.P. Marino¹⁶⁸, F. Marroquim^{23a}, Z. Marshall²⁹, F.K. Martens¹⁵⁷, L.F. Marti¹⁶, S. Marti-Garcia¹⁶⁶, B. Martin²⁹, B. Martin⁸⁷, J.P. Martin⁹², T.A. Martin¹⁷, V.J. Martin⁴⁵, B. Martin dit Latour⁴⁸, S. Martin-Haugh¹⁴⁸, M. Martinez¹¹, V. Martinez Outschoorn⁵⁶, A.C. Martyniuk¹⁶⁸, M. Marx⁸¹, F. Marzano^{131a}, A. Marzin¹¹⁰, L. Masetti⁸⁰, T. Mashimo¹⁵⁴, R. Mashinistov⁹³, J. Masik⁸¹, A.L. Maslennikov¹⁰⁶, I. Massa^{19a,19b}, G. Massaro¹⁰⁴, N. Massol⁴, P. Mastrandrea¹⁴⁷, A. Mastroberardino^{36a,36b}, T. Masubuchi¹⁵⁴, P. Matricon¹¹⁴, H. Matsunaga¹⁵⁴, T. Matsushita⁶⁵, C. Mattravers^{117,c}, J. Maurer⁸², S.J. Maxfield⁷², A. Mayne¹³⁸, R. Mazini¹⁵⁰, M. Mazur²⁰, L. Mazzaferro^{132a,132b}, M. Mazzanti^{88a}, S.P. Mc Kee⁸⁶, A. McCann¹⁶⁴, R.L. McCarthy¹⁴⁷, T.G. McCarthy²⁸, N.A. McCubbin¹²⁸, K.W. McFarlane^{55,*}, J.A. Mcfayden¹³⁸, G. Mchedlize^{50b}, T. McLaughlan¹⁷, S.J. McMahon¹²⁸, R.A. McPherson^{168,k}, A. Meade⁸³, J. Mechnich¹⁰⁴, M. Mechtel¹⁷⁴, M. Medinnis⁴¹, R. Meera-Lebbai¹¹⁰, T. Meguro¹¹⁵, R. Mehdiyev⁹², S. Mehlhase³⁵, A. Mehta⁷², K. Meier^{57a}, B. Meirose⁷⁸, C. Melachrinou³⁰, B.R. Mellado Garcia¹⁷², F. Meloni^{88a,88b}, L. Mendoza Navas¹⁶¹, Z. Meng^{150,u}, A. Mengarelli^{19a,19b}, S. Menke⁹⁸, E. Meoni¹⁶⁰, K.M. Mercurio⁵⁶, P. Mermoud⁴⁸, L. Merola^{101a,101b}, C. Meroni^{88a}, F.S. Merritt³⁰, H. Merritt¹⁰⁸, A. Messina^{29,y}, J. Metcalfe¹⁰², A.S. Mete¹⁶², C. Meyer⁸⁰, C. Meyer³⁰, J.-P. Meyer¹³⁵, J. Meyer¹⁷³, J. Meyer⁵³, T.C. Meyer²⁹, J. Miao^{32d}, S. Michal²⁹, L. Micu^{25a}, R.P. Middleton¹²⁸, S. Migas⁷², L. Mijović¹³⁵, G. Mikenberg¹⁷¹, M. Mikestikova¹²⁴, M. Mikuž⁷³, D.W. Miller³⁰, R.J. Miller⁸⁷, W.J. Mills¹⁶⁷, C. Mills⁵⁶, A. Milov¹⁷¹, D.A. Milstead^{145a,145b}, D. Milstein¹⁷¹, A.A. Minaenko¹²⁷, M. Miñano Moya¹⁶⁶, I.A. Minashvili⁶³, A.I. Mincer¹⁰⁷, B. Mindur³⁷, M. Mineev⁶³, Y. Ming¹⁷², L.M. Mir¹¹, G. Mirabelli^{131a}, J. Mitrevski¹³⁶, V.A. Mitsou¹⁶⁶, S. Mitsui⁶⁴, P.S. Miyagawa¹³⁸, J.U. Mjörnmark⁷⁸, T. Moa^{145a,145b}, V. Moeller²⁷, K. Mönig⁴¹, N. Möser²⁰, S. Mohapatra¹⁴⁷, W. Mohr⁴⁷, R. Moles-Valls¹⁶⁶, A. Molfetas²⁹, J. Monk⁷⁶, E. Monnier⁸², J. Montejo Berlingen¹¹, F. Monticelli⁶⁹, S. Monzani^{19a,19b}, R.W. Moore², G.F. Moorhead⁸⁵, C. Mora Herrera⁴⁸, A. Moraes⁵², N. Morange¹³⁵, J. Morel⁵³, G. Morello^{36a,36b}, D. Moreno⁸⁰, M. Moreno Llácer¹⁶⁶, P. Morettini^{49a}, M. Morgenstern⁴³, M. Morii⁵⁶, A.K. Morley²⁹, G. Mornacchi²⁹, J.D. Morris⁷⁴, L. Morvaj¹⁰⁰, H.G. Moser⁹⁸, M. Mosidze^{50b}, J. Moss¹⁰⁸, R. Mount¹⁴², E. Mountricha^{9,z}, S.V. Mouraviev^{93,*}, E.J.W. Moyse⁸³, F. Mueller^{57a}, J. Mueller¹²², K. Mueller²⁰, T.A. Müller⁹⁷, T. Mueller⁸⁰, D. Muenstermann²⁹, Y. Munwes¹⁵², W.J. Murray¹²⁸, I. Mussche¹⁰⁴, E. Musto^{101a,101b}, A.G. Myagkov¹²⁷, M. Myska¹²⁴, J. Nadal¹¹, K. Nagai¹⁵⁹, R. Nagai¹⁵⁶, K. Nagano⁶⁴, A. Nagarkar¹⁰⁸, Y. Nagasaka⁵⁸, M. Nagel⁹⁸, A.M. Nairz²⁹, Y. Nakahama²⁹, K. Nakamura¹⁵⁴, T. Nakamura¹⁵⁴, I. Nakano¹⁰⁹, G. Nanava²⁰, A. Napier¹⁶⁰, R. Narayan^{57b}, M. Nash^{76,c}, T. Nattermann²⁰, T. Naumann⁴¹, G. Navarro¹⁶¹, H.A. Neal⁸⁶, P.Yu. Nechaeva⁹³, T.J. Neep⁸¹, A. Negri^{118a,118b}, G. Negri²⁹, M. Negrini^{19a}, S. Nektarijevic⁴⁸, A. Nelson¹⁶², T.K. Nelson¹⁴², S. Nemecek¹²⁴, P. Nemethy¹⁰⁷, A.A. Nepomuceno^{23a}, M. Nessi^{29,aa}, M.S. Neubauer¹⁶⁴, A. Neusiedl⁸⁰, R.M. Neves¹⁰⁷, P. Nevski²⁴, F.M. Newcomer¹¹⁹, P.R. Newman¹⁷, V. Nguyen Thi Hong¹³⁵, R.B. Nickerson¹¹⁷, R. Nicolaidou¹³⁵, B. Nicquevert²⁹, F. Niedercorn¹¹⁴, J. Nielsen¹³⁶, N. Nikiforou³⁴, A. Nikiforov¹⁵, V. Nikolaenko¹²⁷, I. Nikolic-Audit⁷⁷, K. Nikolics⁴⁸, K. Nikolopoulos¹⁷, H. Nilsen⁴⁷, P. Nilsson⁷, Y. Ninomiya¹⁵⁴, A. Nisati^{131a}, R. Nisius⁹⁸, T. Nobe¹⁵⁶, L. Nodulman⁵, M. Nomachi¹¹⁵, I. Nomidis¹⁵³, S. Norberg¹¹⁰, M. Nordberg²⁹, P.R. Norton¹²⁸, J. Novakova¹²⁵, M. Nozaki⁶⁴, L. Nozka¹¹², I.M. Nugent^{158a}, A.-E. Nuncio-Quiroz²⁰, G. Nunes Hanninger⁸⁵, T. Nunnemann⁹⁷, E. Nurse⁷⁶, B.J. O'Brien⁴⁵, S.W. O'Neale^{17,*}, D.C. O'Neil¹⁴¹, V. O'Shea⁵², L.B. Oakes⁹⁷, F.G. Oakham^{28,d}, H. Oberlack⁹⁸, J. Ocariz⁷⁷, A. Och⁶⁵, S. Oda⁶⁸, S. Odaka⁶⁴, J. Odier⁸², H. Ogren⁵⁹, A. Oh⁸¹, S.H. Oh⁴⁴, C.C. Ohm²⁹, T. Ohshima¹⁰⁰, H. Okawa²⁴, Y. Okumura³⁰, T. Okuyama¹⁵⁴, A. Olariu^{25a}, A.G. Olchevski⁶³, S.A. Olivares Pino^{31a}, M. Oliveira^{123a,h}, D. Oliveira Damazio²⁴, E. Oliver Garcia¹⁶⁶, D. Olivito¹¹⁹, A. Olszewski³⁸, J. Olszowska³⁸, A. Onofre^{123a,ab}, P.U.E. Onyisi³⁰, C.J. Oram^{158a}, M.J. Oreglia³⁰, Y. Oren¹⁵², D. Orestano^{133a,133b}, N. Orlando^{71a,71b}, I. Orlov¹⁰⁶, C. Oropeza Barrera⁵², R.S. Ori¹⁵⁷, B. Osculati^{49a,49b}, R. Ospanov¹¹⁹, C. Osuna¹¹, G. Otero y Garzon²⁶, J.P. Ottersbach¹⁰⁴, M. Ouchrif^{134d}, E.A. Ouellette¹⁶⁸, F. Ould-Saada¹¹⁶, A. Ouraou¹³⁵, Q. Ouyang^{32a}, A. Ovcharova¹⁴, M. Owen⁸¹, S. Owen¹³⁸, V.E. Ozcan^{18a}, N. Ozturk⁷, A. Pacheco Pages¹¹, C. Padilla Aranda¹¹, S. Pagan Griso¹⁴, E. Paganis¹³⁸, C. Pahl⁹⁸, F. Paige²⁴, P. Pais⁸³, K. Pajchel¹¹⁶, G. Palacino^{158b}, C.P. Paleari⁶, S. Palestini²⁹, D. Pallin³³, A. Palma^{123a}, J.D. Palmer¹⁷, Y.B. Pan¹⁷², E. Panagiotopoulou⁹, P. Pani¹⁰⁴, N. Panikashvili⁸⁶, S. Panitkin²⁴, D. Pantea^{25a}, A. Papadelis^{145a}, Th.D. Papadopolou⁹, A. Paramonov⁵, D. Paredes Hernandez³³, W. Park^{24,ac}, M.A. Parker²⁷, F. Parodi^{49a,49b}, J.A. Parsons³⁴, U. Parzefall⁴⁷, S. Pashapour⁵³, E. Pasqualucci^{131a}, S. Passaggio^{49a}, A. Passeri^{133a}, F. Pastore^{133a,133b,*}, Fr. Pastore⁷⁵, G. Pásztor^{48,ad}, S. Patariaia¹⁷⁴, N. Patel¹⁴⁹, J.R. Pater⁸¹, S. Patricelli^{101a,101b}, T. Pauly²⁹, M. Pecs^{143a}, M.I. Pedraza Morales¹⁷², S.V. Peleganchuk¹⁰⁶, D. Pelikan¹⁶⁵, H. Peng^{32b}, B. Penning³⁰, A. Penson³⁴, J. Penwell⁵⁹, M. Perantoni^{23a}, K. Perez^{34,ae}, T. Perez Cavalcanti⁴¹, E. Perez Codina^{158a}, M.T. Pérez García-Están¹⁶⁶, V. Perez Reale³⁴, L. Perini^{88a,88b}, H. Pernegger²⁹, R. Perrino^{71a}, P. Perrodo⁴, V.D. Peshekhonov⁶³, K. Peters²⁹, B.A. Petersen²⁹, J. Petersen²⁹, T.C. Petersen³⁵, E. Petit⁴, A. Petridis¹⁵³, C. Petridou¹⁵³, E. Petrolo^{131a}, F. Petrucci^{133a,133b}, D. Petschull⁴¹, M. Petteni¹⁴¹, R. Pezoa^{31b}, A. Phan⁸⁵, P.W. Phillips¹²⁸, G. Piacquadio²⁹, A. Picazio⁴⁸, E. Piccaro⁷⁴, M. Piccinini^{19a,19b}, S.M. Piec⁴¹, R. Piegai²⁶, D.T. Pignotti¹⁰⁸, J.E. Pilcher³⁰, A.D. Pilkington⁸¹, J. Pina^{123a,b}, M. Pinamonti^{163a,163c}, A. Pinder¹¹⁷, J.L. Pinfold², B. Pinto^{123a}, C. Pizio^{88a,88b}, M. Plamondon¹⁶⁸, M.-A. Pleier²⁴, E. Plotnikova⁶³, A. Poblaguev²⁴, S. Poddar^{57a}, F. Podlyski³³, L. Poggioli¹¹⁴, M. Pohl⁴⁸, G. Polesello^{118a}, A. Policicchio^{36a,36b}, A. Polini^{19a}, J. Poll⁷⁴, V. Polychronakos²⁴, D. Pomeroy²², K. Pommès²⁹, L. Pontecorvo^{131a}, B.G. Pope⁸⁷, G.A. Popeneciu^{25a}, D.S. Popovic^{12a}, A. Poppleton²⁹, X. Portell Bueso²⁹, G.E. Pospelov⁹⁸,

- S. Pospisil¹²⁶, I.N. Potrap⁹⁸, C.J. Potter¹⁴⁸, C.T. Potter¹¹³, G. Poulard²⁹, J. Poveda⁵⁹, V. Pozdnyakov⁶³, R. Prabhu⁷⁶, P. Pralavorio⁸², A. Pranko¹⁴, S. Prasad²⁹, R. Pravahan²⁴, S. Prell⁶², K. Pretzl¹⁶, D. Price⁵⁹, J. Price⁷², L.E. Price⁵, D. Prieur¹²², M. Primavera^{71a}, K. Prokofiev¹⁰⁷, F. Prokoshin^{31b}, S. Protopopescu²⁴, J. Proudfoot⁵, X. Prudent⁴³, M. Przybycien³⁷, H. Przysieznik⁴, S. Psoroulas²⁰, E. Ptacek¹¹³, E. Pueschel⁸³, J. Purdham⁸⁶, M. Purohit^{24,ac}, P. Puzo¹¹⁴, Y. Pylypchenko⁶¹, J. Qian⁸⁶, A. Quadt⁵³, D.R. Quarrie¹⁴, W.B. Quayle¹⁷², F. Quinonez^{31a}, M. Raas¹⁰³, V. Radeka²⁴, V. Radescu⁴¹, P. Radloff¹¹³, T. Rador^{18a}, F. Ragusa^{88a,88b}, G. Rahal¹⁷⁷, A.M. Rahimi¹⁰⁸, D. Rahm²⁴, S. Rajagopalan²⁴, M. Rammensee⁴⁷, M. Rammes¹⁴⁰, A.S. Randle-Conde³⁹, K. Randrianarivony²⁸, F. Rauscher⁹⁷, T.C. Rave⁴⁷, M. Raymond²⁹, A.L. Read¹¹⁶, D.M. Rebuzzi^{118a,118b}, A. Redelbach¹⁷³, G. Redlinger²⁴, R. Reece¹¹⁹, K. Reeves⁴⁰, E. Reinherz-Aronis¹⁵², A. Reinsch¹¹³, I. Reisinger⁴², C. Rembser²⁹, Z.L. Ren¹⁵⁰, A. Renaud¹¹⁴, M. Rescigno^{131a}, S. Resconi^{88a}, B. Resende¹³⁵, P. Reznicek⁹⁷, R. Rezvani¹⁵⁷, R. Richter⁹⁸, E. Richter-Was^{4,af}, M. Ridet⁷⁷, M. Rijpstra¹⁰⁴, M. Rijssenbeek¹⁴⁷, A. Rimoldi^{118a,118b}, L. Rinaldi^{19a}, R.R. Rios³⁹, I. Riu¹¹, G. Rivoltella^{88a,88b}, F. Rizatdinova¹¹¹, E. Rizvi⁷⁴, S.H. Robertson^{84,k}, A. Robichaud-Veronneau¹¹⁷, D. Robinson²⁷, J.E.M. Robinson⁸¹, A. Robson⁵², J.G. Rocha de Lima¹⁰⁵, C. Roda^{121a,121b}, D. Roda Dos Santos²⁹, A. Roe⁵³, S. Roe²⁹, O. Røhne¹¹⁶, S. Rolli¹⁶⁰, A. Romaniouk⁹⁵, M. Romano^{19a,19b}, G. Romeo²⁶, E. Romero Adam¹⁶⁶, L. Roos⁷⁷, E. Ros¹⁶⁶, S. Rosati^{131a}, K. Rosbach⁴⁸, A. Rose¹⁴⁸, M. Rose⁷⁵, G.A. Rosenbaum¹⁵⁷, E.I. Rosenberg⁶², P.L. Rosendahl¹³, O. Rosenthal¹⁴⁰, L. Rosselet⁴⁸, V. Rossetti¹¹, E. Rossi^{131a,131b}, L.P. Rossi^{49a}, M. Rotaru^{25a}, I. Roth¹⁷¹, J. Rothberg¹³⁷, D. Rousseau¹¹⁴, C.R. Royon¹³⁵, A. Rozanov⁸², Y. Rozen¹⁵¹, X. Ruan^{32a,ag}, F. Rubbo¹¹, I. Rubinskiy⁴¹, B. Ruckert⁹⁷, N. Ruckstuhl¹⁰⁴, V.I. Rud⁹⁶, C. Rudolph⁴³, G. Rudolph⁶⁰, F. Rühr⁶, A. Ruiz-Martinez⁶², L. Rumyantsev⁶³, Z. Rurikova⁴⁷, N.A. Rusakovich⁶³, J.P. Rutherford⁶, C. Ruwiedel^{14,*}, P. Ruzicka¹²⁴, Y.F. Ryabov¹²⁰, P. Ryan⁸⁷, M. Rybar¹²⁵, G. Rybkin¹¹⁴, N.C. Ryder¹¹⁷, A.F. Saavedra¹⁴⁹, I. Sadeh¹⁵², H.F.-W. Sadrozinski¹³⁶, R. Sadykov⁶³, F. Safai Tehrani^{131a}, H. Sakamoto¹⁵⁴, G. Salamanna⁷⁴, A. Salamon^{132a}, M. Saleem¹¹⁰, D. Salek²⁹, D. Salihagic⁹⁸, A. Salnikov¹⁴², J. Salt¹⁶⁶, B.M. Salvachua Ferrando⁵, D. Salvatore^{36a,36b}, F. Salvatore¹⁴⁸, A. Salvucci¹⁰³, A. Salzburger²⁹, D. Sampsonidis¹⁵³, B.H. Samset¹¹⁶, A. Sanchez^{101a,101b}, V. Sanchez Martinez¹⁶⁶, H. Sandaker¹³, H.G. Sander⁸⁰, M.P. Sanders⁹⁷, M. Sandhoff¹⁷⁴, T. Sandoval²⁷, C. Sandoval¹⁶¹, R. Sandstroem⁹⁸, D.P.C. Sankey¹²⁸, A. Sansoni⁴⁶, C. Santamarina Rios⁸⁴, C. Santoni³³, R. Santonico^{132a,132b}, H. Santos^{123a}, J.G. Saraiva^{123a}, T. Sarangi¹⁷², E. Sarkisyan-Grinbaum⁷, F. Sarri^{121a,121b}, G. Sartisoehn¹⁷⁴, O. Sasaki⁶⁴, Y. Sasaki¹⁵⁴, N. Sasao⁶⁶, I. Satsounkevitch⁸⁹, G. Sauvage^{4,*}, E. Sauvan⁴, J.B. Sauvan¹¹⁴, P. Savard^{157,d}, V. Savinov¹²², D.O. Savu²⁹, L. Sawyer^{24,m}, D.H. Saxon⁵², J. Saxon¹¹⁹, C. Sbarra^{19a}, A. Sbrizzi^{19a,19b}, D.A. Scannicchio¹⁶², M. Scarcella¹⁴⁹, J. Schaarschmidt¹¹⁴, P. Schacht⁹⁸, D. Schaefer¹¹⁹, U. Schäfer⁸⁰, S. Schaepe²⁰, S. Schaetzel^{57b}, A.C. Schaffer¹¹⁴, D. Schaile⁹⁷, R.D. Schamberger¹⁴⁷, A.G. Schamov¹⁰⁶, V. Scharf^{57a}, V.A. Schegelsky¹²⁰, D. Scheirich⁸⁶, M. Schernau¹⁶², M.I. Scherzer³⁴, C. Schiavi^{49a,49b}, J. Schieck⁹⁷, M. Schioppa^{36a,36b}, S. Schlenker²⁹, E. Schmidt⁴⁷, K. Schmieden²⁰, C. Schmitt⁸⁰, S. Schmitt^{57b}, M. Schmitz²⁰, B. Schneider¹⁶, U. Schnoor⁴³, A. Schoening^{57b}, A.L.S. Schorlemmer⁵³, M. Schott²⁹, D. Schouten^{158a}, J. Schovancova¹²⁴, M. Schram⁸⁴, C. Schroeder⁸⁰, N. Schroer^{57c}, M.J. Schultens²⁰, J. Schultes¹⁷⁴, H.-C. Schultz-Coulon^{57a}, H. Schulz¹⁵, M. Schumacher⁴⁷, B.A. Schumm¹³⁶, Ph. Schune¹³⁵, C. Schwanenberger⁸¹, A. Schwartzman¹⁴², Ph. Schwemling⁷⁷, R. Schwienhorst⁸⁷, R. Schwierz⁴³, J. Schwindling¹³⁵, T. Schwindt²⁰, M. Schwoerer⁴, G. Sciolla²², W.G. Scott¹²⁸, J. Searcy¹¹³, G. Sedov⁴¹, E. Sedykh¹²⁰, S.C. Seidel¹⁰², A. Seiden¹³⁶, F. Seifert⁴³, J.M. Seixas^{23a}, G. Sekhniaidze^{101a}, S.J. Sekula³⁹, K.E. Selbach⁴⁵, D.M. Seliverstov¹²⁰, B. Sellden^{145a}, G. Sellers⁷², M. Seman^{143b}, N. Semprini-Cesari^{19a,19b}, C. Serfon⁹⁷, L. Serin¹¹⁴, L. Serkin⁵³, R. Seuster⁹⁸, H. Severini¹¹⁰, A. Sfyrila²⁹, E. Shabalina⁵³, M. Shamim¹¹³, L.Y. Shan^{32a}, J.T. Shank²¹, Q.T. Shao⁸⁵, M. Shapiro¹⁴, P.B. Shatalov⁹⁴, K. Shaw^{163a,163c}, D. Sherman¹⁷⁵, P. Sherwood⁷⁶, A. Shibata¹⁰⁷, S. Shimizu²⁹, M. Shimojima⁹⁹, T. Shin⁵⁵, M. Shiyakova⁶³, A. Shmeleva⁹³, M.J. Shochet³⁰, D. Short¹¹⁷, S. Shrestha⁶², E. Shulga⁹⁵, M.A. Shupe⁶, P. Sicho¹²⁴, A. Sidoti^{131a}, F. Siegert⁴⁷, Dj. Sijacki^{12a}, O. Silbert¹⁷¹, J. Silva^{123a}, Y. Silver¹⁵², D. Silverstein¹⁴², S.B. Silverstein^{145a}, V. Simak¹²⁶, O. Simard¹³⁵, Lj. Simic^{12a}, S. Simion¹¹⁴, E. Simioni⁸⁰, B. Simmons⁷⁶, R. Simoniello^{88a,88b}, M. Simonyan³⁵, P. Sinervo¹⁵⁷, N.B. Sinev¹¹³, V. Sipica¹⁴⁰, G. Siragusa¹⁷³, A. Sircar²⁴, A.N. Sisakyan^{63,*}, S.Yu. Sivoklokov⁹⁶, J. Sjölin^{145a,145b}, T.B. Sjsuren¹³, L.A. Skinner¹⁴, H.P. Skottowe⁵⁶, K. Skovpen¹⁰⁶, P. Skubic¹¹⁰, M. Slater¹⁷, T. Slavicek¹²⁶, K. Sliwa¹⁶⁰, V. Smakhtin¹⁷¹, B.H. Smart⁴⁵, S.Yu. Smirnov⁹⁵, Y. Smirnov⁹⁵, L.N. Smirnova⁹⁶, O. Smirnova⁷⁸, B.C. Smith⁵⁶, D. Smith¹⁴², K.M. Smith⁵², M. Smizanska⁷⁰, K. Smolek¹²⁶, A.A. Snesarev⁹³, S.W. Snow⁸¹, J. Snow¹¹⁰, S. Snyder²⁴, R. Sobie^{168,k}, J. Sodomka¹²⁶, A. Soffer¹⁵², C.A. Solans¹⁶⁶, M. Solar¹²⁶, J. Solc¹²⁶, E.Yu. Soldatov⁹⁵, U. Soldevila¹⁶⁶, E. Solfaroli Camillocci^{131a,131b}, A.A. Solodkov¹²⁷, O.V. Solovyanov¹²⁷, V. Solovye¹²⁰, N. Soni⁸⁵, V. Sopko¹²⁶, B. Sopko¹²⁶, M. Sosebee⁷, R. Soualah^{163a,163c}, A. Soukharev¹⁰⁶, S. Spagnolo^{71a,71b}, F. Spano⁷⁵, R. Spighi^{19a}, G. Spigo²⁹, R. Spiwoks²⁹, M. Spousta^{125,ah}, T. Spreitzer¹⁵⁷, B. Spurlock⁷, R.D. St. Denis⁵², J. Stahlman¹¹⁹, R. Stamen^{57a}, E. Stanecka³⁸, R.W. Stanek⁵, C. Stanescu^{133a}, M. Stanescu-Bellu⁴¹, S. Stapnes¹¹⁶, E.A. Starchenko¹²⁷, J. Stark⁵⁴, P. Staroba¹²⁴, P. Starovoitov⁴¹, R. Staszewski³⁸, A. Staude⁹⁷, P. Stavina^{143a,*}, G. Steele⁵², P. Steinbach⁴³, P. Steinberg²⁴, I. Stekl¹²⁶, B. Stelzer¹⁴¹, H.J. Stelzer⁸⁷, O. Stelzer-Chilton^{158a}, H. Stenzel⁵¹, S. Stern⁹⁸, G.A. Stewart²⁹, J.A. Stillings²⁰, M.C. Stockton⁸⁴, K. Stoerig⁴⁷, G. Stoica^{25a}, S. Stonjek⁹⁸, P. Strachota¹²⁵, A.R. Stradling⁷, A. Straessner⁴³, J. Strandberg¹⁴⁶, S. Strandberg^{145a,145b}, A. Strandlie¹¹⁶, M. Strang¹⁰⁸,

E. Strauss¹⁴², M. Strauss¹¹⁰, P. Strizenec^{143b}, R. Ströhmer¹⁷³, D.M. Strom¹¹³, J.A. Strong^{75,*}, R. Stroynowski³⁹, J. Strube¹²⁸, B. Stugu¹³, I. Stumer^{24,*}, J. Stupak¹⁴⁷, P. Sturm¹⁷⁴, N.A. Styles⁴¹, D.A. Soh^{150,w}, D. Su¹⁴², H.S. Subramania², A. Succurro¹¹, Y. Sugaya¹¹⁵, C. Suhr¹⁰⁵, M. Suk¹²⁵, V.V. Sulin⁹³, S. Sultansoy^{3d}, T. Sumida⁶⁶, X. Sun⁵⁴, J.E. Sundermann⁴⁷, K. Suruliz¹³⁸, G. Susinno^{36a,36b}, M.R. Sutton¹⁴⁸, Y. Suzuki⁶⁴, Y. Suzuki⁶⁵, M. Svatos¹²⁴, S. Swedish¹⁶⁷, I. Sykora^{143a}, T. Sykora¹²⁵, J. Sánchez¹⁶⁶, D. Ta¹⁰⁴, K. Tackmann⁴¹, A. Taffard¹⁶², R. Tafirout^{158a}, N. Taiblum¹⁵², Y. Takahashi¹⁰⁰, H. Takai²⁴, R. Takashima⁶⁷, H. Takeda⁶⁵, T. Takeshita¹³⁹, Y. Takubo⁶⁴, M. Talby⁸², A. Talyshev^{106,f}, M.C. Tamsett²⁴, J. Tanaka¹⁵⁴, R. Tanaka¹¹⁴, S. Tanaka¹³⁰, S. Tanaka⁶⁴, A.J. Tanasijczuk¹⁴¹, K. Tani⁶⁵, N. Tannoury⁸², S. Tapprogge⁸⁰, D. Tardif¹⁵⁷, S. Tarem¹⁵¹, F. Tarrade²⁸, G.F. Tartarelli^{88a}, P. Tas¹²⁵, M. Tasevsky¹²⁴, E. Tassi^{36a,36b}, M. Tatarkhanov¹⁴, Y. Tayalati^{134d}, C. Taylor⁷⁶, F.E. Taylor⁹¹, G.N. Taylor⁸⁵, W. Taylor^{158b}, M. Teinturier¹¹⁴, M. Teixeira Dias Castanheira⁷⁴, P. Teixeira-Dias⁷⁵, K.K. Temming⁴⁷, H. Ten Kate²⁹, P.K. Teng¹⁵⁰, S. Terada⁶⁴, K. Terashi¹⁵⁴, J. Terron⁷⁹, M. Testa⁴⁶, R.J. Teuscher^{157,k}, J. Therhaag²⁰, T. Theveneaux-Pelzer⁷⁷, S. Thoma⁴⁷, J.P. Thomas¹⁷, E.N. Thompson³⁴, P.D. Thompson¹⁷, P.D. Thompson¹⁵⁷, A.S. Thompson⁵², L.A. Thomsen³⁵, E. Thomson¹¹⁹, M. Thomson²⁷, W.M. Thong⁸⁵, R.P. Thun⁸⁶, F. Tian³⁴, M.J. Tibbetts¹⁴, T. Tic¹²⁴, V.O. Tikhomirov⁹³, Y.A. Tikhonov^{106,f}, S. Timoshenko⁹⁵, P. Tipton¹⁷⁵, S. Tisserant⁸², T. Todorov⁴, S. Todorova-Nova¹⁶⁰, B. Toggerson¹⁶², J. Tojo⁶⁸, S. Tokár^{143a}, K. Tokushuku⁶⁴, K. Tollefson⁸⁷, M. Tomoto¹⁰⁰, L. Tompkins³⁰, K. Toms¹⁰², A. Tonoyan¹³, C. Topfel¹⁶, N.D. Topilin⁶³, I. Torchiani²⁹, E. Torrence¹¹³, H. Torres⁷⁷, E. Torró Pastor¹⁶⁶, J. Toth^{82,ad}, F. Touchard⁸², D.R. Tovey¹³⁸, T. Trefzger¹⁷³, L. Tremblet²⁹, A. Tricoli²⁹, I.M. Trigger^{158a}, S. Trincz-Duvoid⁷⁷, M.F. Tripiana⁶⁹, N. Triplett²⁴, W. Trischuk¹⁵⁷, B. Trocme⁵⁴, C. Troncon^{88a}, M. Trotter-McDonald¹⁴¹, M. Trzebinski³⁸, A. Trzupek³⁸, C. Tsarouchas²⁹, J.C.-L. Tseng¹¹⁷, M. Tsiakiris¹⁰⁴, P.V. Tsiareshka⁸⁹, D. Tsionou^{4,ai}, G. Tsipolitis⁹, S. Tsiskaridze¹¹, V. Tsiskaridze⁴⁷, E.G. Tskhadadze^{50a}, I.I. Tsukerman⁹⁴, V. Tsulaia¹⁴, J.-W. Tsung²⁰, S. Tsuno⁶⁴, D. Tsybychev¹⁴⁷, A. Tua¹³⁸, A. Tudorache^{25a}, V. Tudorache^{25a}, J.M. Tuggle³⁰, M. Turala³⁸, D. Turecek¹²⁶, I. Turk Cakir^{3e}, E. Turlay¹⁰⁴, R. Turra^{88a,88b}, P.M. Tuts³⁴, A. Tykhonov⁷³, M. Tylmad^{145a,145b}, M. Tyndel¹²⁸, G. Tzanakos⁸, K. Uchida²⁰, I. Ueda¹⁵⁴, R. Ueno²⁸, M. Ugland¹³, M. Uhlenbrock²⁰, M. Uhrmacher⁵³, F. Ukegawa¹⁵⁹, G. Unal²⁹, A. Undrus²⁴, G. Unel¹⁶², Y. Unno⁶⁴, D. Urbaniec³⁴, G. Usai⁷, M. Uslenghi^{118a,118b}, L. Vacavant⁸², V. Vacek¹²⁶, B. Vachon⁸⁴, S. Vahsen¹⁴, J. Valenta¹²⁴, S. Valentineti^{19a,19b}, A. Valero¹⁶⁶, S. Valkar¹²⁵, E. Valladolid Gallego¹⁶⁶, S. Vallecorsa¹⁵¹, J.A. Valls Ferrer¹⁶⁶, R. Van Berg¹¹⁹, P.C. Van Der Deijl¹⁰⁴, R. van der Geer¹⁰⁴, H. van der Graaf¹⁰⁴, R. Van Der Leeuw¹⁰⁴, E. van der Poel¹⁰⁴, D. van der Ster²⁹, N. van Eldik²⁹, P. van Gemmeren⁵, I. van Vulpen¹⁰⁴, M. Vanadia⁹⁸, W. Vandelli²⁹, A. Vaniachine⁵, P. Vankov⁴¹, F. Vannucci⁷⁷, R. Vari^{131a}, T. Varol⁸³, D. Varouchas¹⁴, A. Vartapetian⁷, K.E. Varvell¹⁴⁹, V.I. Vassilakopoulos⁵⁵, F. Vazeille³³, T. Vazquez Schroeder⁵³, G. Vegni^{88a,88b}, J.J. Veillet¹¹⁴, F. Veloso^{123a}, R. Veness²⁹, S. Veneziano^{131a}, A. Ventura^{71a,71b}, D. Ventura⁸³, M. Venturi⁴⁷, N. Venturi¹⁵⁷, V. Vercesi^{118a}, M. Verducci¹³⁷, W. Verkerke¹⁰⁴, J.C. Vermeulen¹⁰⁴, A. Vest⁴³, M.C. Vetterli^{141,d}, I. Vichou¹⁶⁴, T. Vickey^{144b,aj}, O.E. Vickey Boeriu^{144b}, G.H.A. Viehhauser¹¹⁷, S. Viel¹⁶⁷, M. Villa^{19a,19b}, M. Villaplana Perez¹⁶⁶, E. Vilucchi⁴⁶, M.G. Vincet²⁸, E. Vinek²⁹, V.B. Vinogradov⁶³, M. Virchaux^{135,*}, J. Virzi¹⁴, O. Vitells¹⁷¹, M. Viti⁴¹, I. Vivarelli⁴⁷, F. Vives Vaque², S. Vlachos⁹, D. Vladoiu⁹⁷, M. Vlasak¹²⁶, A. Vogel²⁰, P. Vokac¹²⁶, G. Volpi⁴⁶, M. Volpi⁸⁵, G. Volpini^{88a}, H. von der Schmitt⁹⁸, H. von Radziewski⁴⁷, E. von Toerne²⁰, V. Vorobel¹²⁵, V. Vorwerk¹¹, M. Vos¹⁶⁶, R. Voss²⁹, T.T. Voss¹⁷⁴, J.H. Vosseveld⁷², N. Vranjes¹³⁵, M. Vranjes Milosavljevic¹⁰⁴, V. Vrba¹²⁴, M. Vreeswijk¹⁰⁴, T. Vu Anh⁴⁷, R. Vuillemet²⁹, I. Vukotic³⁰, W. Wagner¹⁷⁴, P. Wagner¹¹⁹, H. Wahlen¹⁷⁴, S. Wahrenmund⁴³, J. Wakabayashi¹⁰⁰, S. Walch⁸⁶, J. Walder⁷⁰, R. Walker⁹⁷, W. Walkowiak¹⁴⁰, R. Wall¹⁷⁵, P. Waller⁷², B. Walsh¹⁷⁵, C. Wang⁴⁴, H. Wang¹⁷², H. Wang^{32b,ak}, J. Wang¹⁵⁰, J. Wang⁵⁴, R. Wang¹⁰², S.M. Wang¹⁵⁰, T. Wang²⁰, A. Warburton⁸⁴, C.P. Ward²⁷, M. Warsinsky⁴⁷, A. Washbrook⁴⁵, C. Wasicki⁴¹, I. Watanabe⁶⁵, P.M. Watkins¹⁷, A.T. Watson¹⁷, I.J. Watson¹⁴⁹, M.F. Watson¹⁷, G. Watts¹³⁷, S. Watts⁸¹, A.T. Waugh¹⁴⁹, B.M. Waugh⁷⁶, M. Weber¹²⁸, M.S. Weber¹⁶, P. Weber⁵³, A.R. Weidberg¹¹⁷, P. Weigell⁹⁸, J. Weingarten⁵³, C. Weiser⁴⁷, H. Wellenstein²², P.S. Wells²⁹, T. Wenaus²⁴, D. Wendland¹⁵, Z. Weng^{150,w}, T. Wengler²⁹, S. Wenig²⁹, N. Wermes²⁰, M. Werner⁴⁷, P. Werner²⁹, M. Werth¹⁶², M. Wessels^{57a}, J. Wetter¹⁶⁰, C. Weydert⁵⁴, K. Whalen²⁸, S.J. Wheeler-Ellis¹⁶², A. White⁷, M.J. White⁸⁵, S. White^{121a,121b}, S.R. Whitehead¹¹⁷, D. Whiteson¹⁶², D. Whittington⁵⁹, F. Wicke¹¹⁴, D. Wicke¹⁷⁴, F.J. Wickens¹²⁸, W. Wiedenmann¹⁷², M. Wielers¹²⁸, P. Wienemann²⁰, C. Wigglesworth⁷⁴, L.A.M. Wiik-Fuchs⁴⁷, P.A. Wijeratne⁷⁶, A. Wildauer¹⁶⁶, M.A. Wildt^{41,s}, I. Wilhelm¹²⁵, H.G. Wilkens²⁹, J.Z. Will⁹⁷, E. Williams³⁴, H.H. Williams¹¹⁹, W. Willis³⁴, S. Willocq⁸³, J.A. Wilson¹⁷, M.G. Wilson¹⁴², A. Wilson⁸⁶, I. Wingerter-Seetz⁴, S. Winkelmann⁴⁷, F. Winklmeier²⁹, M. Wittgen¹⁴², S.J. Wollstadt⁸⁰, M.W. Wolter³⁸, H. Wolters^{123a,h}, W.C. Wong⁴⁰, G. Wooden⁸⁶, B.K. Wosiek³⁸, J. Wotschack²⁹, M.J. Woudstra⁸¹, K.W. Wozniak³⁸, K. Wraight⁵², C. Wright⁵², M. Wright⁵², B. Wrona⁷², S.L. Wu¹⁷², X. Wu⁴⁸, Y. Wu^{32b,al}, E. Wulf³⁴, B.M. Wynne⁴⁵, S. Xella³⁵, M. Xiao¹³⁵, S. Xie⁴⁷, C. Xu^{32b,z}, D. Xu¹³⁸, B. Yabsley¹⁴⁹, S. Yacoub^{144b}, M. Yamada⁶⁴, H. Yamaguchi¹⁵⁴, A. Yamamoto⁶⁴, K. Yamamoto⁶², S. Yamamoto¹⁵⁴, T. Yamamura¹⁵⁴, T. Yamanaka¹⁵⁴, J. Yamaoka⁴⁴, T. Yamazaki¹⁵⁴, Y. Yamazaki⁶⁵, Z. Yan²¹, H. Yang⁸⁶, U.K. Yang⁸¹, Y. Yang⁵⁹, Z. Yang^{145a,145b}, S. Yanush⁹⁰, L. Yao^{32a}, Y. Yao¹⁴, Y. Yasu⁶⁴, G.V. Ybeles Smit¹²⁹, J. Ye³⁹, S. Ye²⁴, M. Yilmaz^{3c}, R. Yoosoofmiya¹²², K. Yorita¹⁷⁰, R. Yoshida⁵, C. Young¹⁴², C.J. Young¹¹⁷, S. Youssef²¹, D. Yu²⁴, J. Yu⁷, J. Yu¹¹¹, L. Yuan⁶⁵, A. Yurkewicz¹⁰⁵, M. Byszewski²⁹, B. Zabinski³⁸,

R. Zaidan⁶¹, A.M. Zaitsev¹²⁷, Z. Zajacova²⁹, L. Zanello^{131a,131b}, A. Zaytsev¹⁰⁶, C. Zeitnitz¹⁷⁴, M. Zeman¹²⁴, A. Zemla³⁸, C. Zendler²⁰, O. Zenin¹²⁷, T. Ženiš^{143a}, Z. Zinonos^{121a,121b}, S. Zenz¹⁴, D. Zerwas¹¹⁴, G. Zevi della Porta⁵⁶, Z. Zhan^{32d}, D. Zhang^{32b,ak}, H. Zhang⁸⁷, J. Zhang⁵, X. Zhang^{32d}, Z. Zhang¹¹⁴, L. Zhao¹⁰⁷, T. Zhao¹³⁷, Z. Zhao^{32b}, A. Zhemchugov⁶³, J. Zhong¹¹⁷, B. Zhou⁸⁶, N. Zhou¹⁶², Y. Zhou¹⁵⁰, C.G. Zhu^{32d}, H. Zhu⁴¹, J. Zhu⁸⁶, Y. Zhu^{32b}, X. Zhuang⁹⁷, V. Zhuravlov⁹⁸, D. Zieminska⁵⁹, N.I. Zimin⁶³, R. Zimmermann²⁰, S. Zimmermann²⁰, S. Zimmermann⁴⁷, M. Ziolkowski¹⁴⁰, R. Zitoun⁴, L. Živković³⁴, V.V. Zmouchko^{127,*}, G. Zobernig¹⁷², A. Zoccoli^{19a,19b}, M. zur Nedden¹⁵, V. Zutshi¹⁰⁵, L. Zwalinski²⁹

¹Physics Department, SUNY Albany, Albany NY, United States of America

²Department of Physics, University of Alberta, Edmonton AB, Canada

^{3(a)}Department of Physics, Ankara University, Ankara; ^(b)Department of Physics, Dumlupinar University, Kutahya;

^(c)Department of Physics, Gazi University, Ankara; ^(d)Division of Physics, TOBB University of Economics and Technology, Ankara; ^(e)Turkish Atomic Energy Authority, Ankara, Turkey

⁴LAPP, CNRS/IN2P3 and Université de Savoie, Annecy-le-Vieux, France

⁵High Energy Physics Division, Argonne National Laboratory, Argonne IL, United States of America

⁶Department of Physics, University of Arizona, Tucson AZ, United States of America

⁷Department of Physics, The University of Texas at Arlington, Arlington TX, United States of America

⁸Physics Department, University of Athens, Athens, Greece

⁹Physics Department, National Technical University of Athens, Zografou, Greece

¹⁰Institute of Physics, Azerbaijan Academy of Sciences, Baku, Azerbaijan

¹¹Institut de Física d'Altes Energies and Departament de Física de la Universitat Autònoma de Barcelona and ICREA, Barcelona, Spain

^{12(a)}Institute of Physics, University of Belgrade, Belgrade; ^(b)Vinca Institute of Nuclear Sciences, University of Belgrade, Belgrade, Serbia

¹³Department for Physics and Technology, University of Bergen, Bergen, Norway

¹⁴Physics Division, Lawrence Berkeley National Laboratory and University of California, Berkeley CA, United States of America

¹⁵Department of Physics, Humboldt University, Berlin, Germany

¹⁶Albert Einstein Center for Fundamental Physics and Laboratory for High Energy Physics, University of Bern, Bern, Switzerland

¹⁷School of Physics and Astronomy, University of Birmingham, Birmingham, United Kingdom

^{18(a)}Department of Physics, Bogazici University, Istanbul; ^(b)Division of Physics, Dogus University, Istanbul;

^(c)Department of Physics Engineering, Gaziantep University, Gaziantep; ^(d)Department of Physics, Istanbul Technical University, Istanbul, Turkey

^{19(a)}INFN Sezione di Bologna; ^(b)Dipartimento di Fisica, Università di Bologna, Bologna, Italy

²⁰Physikalisches Institut, University of Bonn, Bonn, Germany

²¹Department of Physics, Boston University, Boston MA, United States of America

²²Department of Physics, Brandeis University, Waltham MA, United States of America

^{23(a)}Universidade Federal do Rio De Janeiro COPPE/EE/IF, Rio de Janeiro; ^(b)Federal University of Juiz de Fora (UFJF), Juiz de Fora; ^(c)Federal University of Sao Joao del Rei (UFSJ), Sao Joao del Rei; ^(d)Instituto de Física, Universidade de Sao Paulo, Sao Paulo, Brazil

²⁴Physics Department, Brookhaven National Laboratory, Upton NY, United States of America

^{25(a)}National Institute of Physics and Nuclear Engineering, Bucharest; ^(b)University Politehnica Bucharest, Bucharest;

^(c)West University in Timisoara, Timisoara, Romania

²⁶Departamento de Física, Universidad de Buenos Aires, Buenos Aires, Argentina

²⁷Cavendish Laboratory, University of Cambridge, Cambridge, United Kingdom

²⁸Department of Physics, Carleton University, Ottawa ON, Canada

²⁹CERN, Geneva, Switzerland

³⁰Enrico Fermi Institute, University of Chicago, Chicago IL, United States of America

^{31(a)}Departamento de Física, Pontificia Universidad Católica de Chile, Santiago; ^(b)Departamento de Física, Universidad Técnica Federico Santa María, Valparaíso, Chile

^{32(a)}Institute of High Energy Physics, Chinese Academy of Sciences, Beijing; ^(b)Department of Modern Physics, University of Science and Technology of China, Anhui; ^(c)Department of Physics, Nanjing University, Jiangsu; ^(d)School of Physics, Shandong University, Shandong, China

- ³³Laboratoire de Physique Corpusculaire, Clermont Université and Université Blaise Pascal and CNRS/IN2P3, Clermont-Ferrand, France
- ³⁴Nevis Laboratory, Columbia University, Irvington NY, United States of America
- ³⁵Niels Bohr Institute, University of Copenhagen, Kobenhavn, Denmark
- ³⁶(a) INFN Gruppo Collegato di Cosenza; (b) Dipartimento di Fisica, Università della Calabria, Arcavata di Rende, Italy
- ³⁷AGH University of Science and Technology, Faculty of Physics and Applied Computer Science, Krakow, Poland
- ³⁸The Henryk Niewodniczanski Institute of Nuclear Physics, Polish Academy of Sciences, Krakow, Poland
- ³⁹Physics Department, Southern Methodist University, Dallas TX, United States of America
- ⁴⁰Physics Department, University of Texas at Dallas, Richardson TX, United States of America
- ⁴¹DESY, Hamburg and Zeuthen, Germany
- ⁴²Institut für Experimentelle Physik IV, Technische Universität Dortmund, Dortmund, Germany
- ⁴³Institut für Kern- und Teilchenphysik, Technical University Dresden, Dresden, Germany
- ⁴⁴Department of Physics, Duke University, Durham NC, United States of America
- ⁴⁵SUPA - School of Physics and Astronomy, University of Edinburgh, Edinburgh, United Kingdom
- ⁴⁶INFN Laboratori Nazionali di Frascati, Frascati, Italy
- ⁴⁷Fakultät für Mathematik und Physik, Albert-Ludwigs-Universität, Freiburg, Germany
- ⁴⁸Section de Physique, Université de Genève, Geneva, Switzerland
- ⁴⁹(a) INFN Sezione di Genova; (b) Dipartimento di Fisica, Università di Genova, Genova, Italy
- ⁵⁰(a) E. Andronikashvili Institute of Physics, Tbilisi State University, Tbilisi; (b) High Energy Physics Institute, Tbilisi State University, Tbilisi, Georgia
- ⁵¹II Physikalisches Institut, Justus-Liebig-Universität Giessen, Giessen, Germany
- ⁵²SUPA - School of Physics and Astronomy, University of Glasgow, Glasgow, United Kingdom
- ⁵³II Physikalisches Institut, Georg-August-Universität, Göttingen, Germany
- ⁵⁴Laboratoire de Physique Subatomique et de Cosmologie, Université Joseph Fourier and CNRS/IN2P3 and Institut National Polytechnique de Grenoble, Grenoble, France
- ⁵⁵Department of Physics, Hampton University, Hampton VA, United States of America
- ⁵⁶Laboratory for Particle Physics and Cosmology, Harvard University, Cambridge MA, United States of America
- ⁵⁷(a) Kirchhoff-Institut für Physik, Ruprecht-Karls-Universität Heidelberg, Heidelberg; (b) Physikalisches Institut, Ruprecht-Karls-Universität Heidelberg, Heidelberg; (c) ZITI Institut für technische Informatik, Ruprecht-Karls-Universität Heidelberg, Mannheim, Germany
- ⁵⁸Faculty of Applied Information Science, Hiroshima Institute of Technology, Hiroshima, Japan
- ⁵⁹Department of Physics, Indiana University, Bloomington IN, United States of America
- ⁶⁰Institut für Astro- und Teilchenphysik, Leopold-Franzens-Universität, Innsbruck, Austria
- ⁶¹University of Iowa, Iowa City IA, United States of America
- ⁶²Department of Physics and Astronomy, Iowa State University, Ames IA, United States of America
- ⁶³Joint Institute for Nuclear Research, JINR Dubna, Dubna, Russia
- ⁶⁴KEK, High Energy Accelerator Research Organization, Tsukuba, Japan
- ⁶⁵Graduate School of Science, Kobe University, Kobe, Japan
- ⁶⁶Faculty of Science, Kyoto University, Kyoto, Japan
- ⁶⁷Kyoto University of Education, Kyoto, Japan
- ⁶⁸Department of Physics, Kyushu University, Fukuoka, Japan
- ⁶⁹Instituto de Física La Plata, Universidad Nacional de La Plata and CONICET, La Plata, Argentina
- ⁷⁰Physics Department, Lancaster University, Lancaster, United Kingdom
- ⁷¹(a) INFN Sezione di Lecce; (b) Dipartimento di Matematica e Fisica, Università del Salento, Lecce, Italy
- ⁷²Oliver Lodge Laboratory, University of Liverpool, Liverpool, United Kingdom
- ⁷³Department of Physics, Jožef Stefan Institute and University of Ljubljana, Ljubljana, Slovenia
- ⁷⁴School of Physics and Astronomy, Queen Mary University of London, London, United Kingdom
- ⁷⁵Department of Physics, Royal Holloway University of London, Surrey, United Kingdom
- ⁷⁶Department of Physics and Astronomy, University College London, London, United Kingdom
- ⁷⁷Laboratoire de Physique Nucléaire et de Hautes Energies, UPMC and Université Paris-Diderot and CNRS/IN2P3, Paris, France
- ⁷⁸Fysiska institutionen, Lunds universitet, Lund, Sweden
- ⁷⁹Departamento de Física Teórica C-15, Universidad Autónoma de Madrid, Madrid, Spain

- ⁸⁰Institut für Physik, Universität Mainz, Mainz, Germany
- ⁸¹School of Physics and Astronomy, University of Manchester, Manchester, United Kingdom
- ⁸²CPPM, Aix-Marseille Université and CNRS/IN2P3, Marseille, France
- ⁸³Department of Physics, University of Massachusetts, Amherst MA, United States of America
- ⁸⁴Department of Physics, McGill University, Montreal QC, Canada
- ⁸⁵School of Physics, University of Melbourne, Victoria, Australia
- ⁸⁶Department of Physics, The University of Michigan, Ann Arbor MI, United States of America
- ⁸⁷Department of Physics and Astronomy, Michigan State University, East Lansing MI, United States of America
- ⁸⁸(a)INFN Sezione di Milano; (b)Dipartimento di Fisica, Università di Milano, Milano, Italy
- ⁸⁹B.I. Stepanov Institute of Physics, National Academy of Sciences of Belarus, Minsk, Republic of Belarus
- ⁹⁰National Scientific and Educational Centre for Particle and High Energy Physics, Minsk, Republic of Belarus
- ⁹¹Department of Physics, Massachusetts Institute of Technology, Cambridge MA, United States of America
- ⁹²Group of Particle Physics, University of Montreal, Montreal QC, Canada
- ⁹³P.N. Lebedev Institute of Physics, Academy of Sciences, Moscow, Russia
- ⁹⁴Institute for Theoretical and Experimental Physics (ITEP), Moscow, Russia
- ⁹⁵Moscow Engineering and Physics Institute (MEPhI), Moscow, Russia
- ⁹⁶Skobeltsyn Institute of Nuclear Physics, Lomonosov Moscow State University, Moscow, Russia
- ⁹⁷Fakultät für Physik, Ludwig-Maximilians-Universität München, München, Germany
- ⁹⁸Max-Planck-Institut für Physik (Werner-Heisenberg-Institut), München, Germany
- ⁹⁹Nagasaki Institute of Applied Science, Nagasaki, Japan
- ¹⁰⁰Graduate School of Science and Kobayashi-Maskawa Institute, Nagoya University, Nagoya, Japan
- ¹⁰¹(a)INFN Sezione di Napoli; (b)Dipartimento di Scienze Fisiche, Università di Napoli, Napoli, Italy
- ¹⁰²Department of Physics and Astronomy, University of New Mexico, Albuquerque NM, United States of America
- ¹⁰³Institute for Mathematics, Astrophysics and Particle Physics, Radboud University Nijmegen/Nikhef, Nijmegen, Netherlands
- ¹⁰⁴Nikhef National Institute for Subatomic Physics and University of Amsterdam, Amsterdam, Netherlands
- ¹⁰⁵Department of Physics, Northern Illinois University, DeKalb IL, United States of America
- ¹⁰⁶Budker Institute of Nuclear Physics, SB RAS, Novosibirsk, Russia
- ¹⁰⁷Department of Physics, New York University, New York NY, United States of America
- ¹⁰⁸Ohio State University, Columbus OH, United States of America
- ¹⁰⁹Faculty of Science, Okayama University, Okayama, Japan
- ¹¹⁰Homer L. Dodge Department of Physics and Astronomy, University of Oklahoma, Norman OK, United States of America
- ¹¹¹Department of Physics, Oklahoma State University, Stillwater OK, United States of America
- ¹¹²Palacký University, RCPTM, Olomouc, Czech Republic
- ¹¹³Center for High Energy Physics, University of Oregon, Eugene OR, United States of America
- ¹¹⁴LAL, Université Paris-Sud and CNRS/IN2P3, Orsay, France
- ¹¹⁵Graduate School of Science, Osaka University, Osaka, Japan
- ¹¹⁶Department of Physics, University of Oslo, Oslo, Norway
- ¹¹⁷Department of Physics, Oxford University, Oxford, United Kingdom
- ¹¹⁸(a)INFN Sezione di Pavia; (b)Dipartimento di Fisica, Università di Pavia, Pavia, Italy
- ¹¹⁹Department of Physics, University of Pennsylvania, Philadelphia PA, United States of America
- ¹²⁰Petersburg Nuclear Physics Institute, Gatchina, Russia
- ¹²¹(a)INFN Sezione di Pisa; (b)Dipartimento di Fisica E. Fermi, Università di Pisa, Pisa, Italy
- ¹²²Department of Physics and Astronomy, University of Pittsburgh, Pittsburgh PA, United States of America
- ¹²³(a)Laboratorio de Instrumentacao e Fisica Experimental de Particulas - LIP, Lisboa, Portugal; (b)Departamento de Fisica Teorica y del Cosmos and CAFPE, Universidad de Granada, Granada, Spain
- ¹²⁴Institute of Physics, Academy of Sciences of the Czech Republic, Praha, Czech Republic
- ¹²⁵Faculty of Mathematics and Physics, Charles University in Prague, Praha, Czech Republic
- ¹²⁶Czech Technical University in Prague, Praha, Czech Republic
- ¹²⁷State Research Center Institute for High Energy Physics, Protvino, Russia
- ¹²⁸Particle Physics Department, Rutherford Appleton Laboratory, Didcot, United Kingdom
- ¹²⁹Physics Department, University of Regina, Regina SK, Canada

- ¹³⁰Ritsumeikan University, Kusatsu, Shiga, Japan
- ¹³¹(a)INFN Sezione di Roma I; (b)Dipartimento di Fisica, Università La Sapienza, Roma, Italy
- ¹³²(a)INFN Sezione di Roma Tor Vergata; (b)Dipartimento di Fisica, Università di Roma Tor Vergata, Roma, Italy
- ¹³³(a)INFN Sezione di Roma Tre; (b)Dipartimento di Fisica, Università Roma Tre, Roma, Italy
- ¹³⁴(a)Faculté des Sciences Ain Chock, Réseau Universitaire de Physique des Hautes Energies - Université Hassan II, Casablanca; (b)Centre National de l'Energie des Sciences Techniques Nucleaires, Rabat; (c)Faculté des Sciences Semlalia, Université Cadi Ayyad, LPHEA, Marrakech; (d)Faculté des Sciences, Université Mohamed Premier and LTPM, Oujda; (e)Faculté des sciences, Université Mohammed V-Agdal, Rabat, Morocco
- ¹³⁵DSM/IRFU (Institut de Recherches sur les Lois Fondamentales de l'Univers), CEA Saclay (Commissariat à l'Energie Atomique), Gif-sur-Yvette, France
- ¹³⁶Santa Cruz Institute for Particle Physics, University of California Santa Cruz, Santa Cruz CA, United States of America
- ¹³⁷Department of Physics, University of Washington, Seattle WA, United States of America
- ¹³⁸Department of Physics and Astronomy, University of Sheffield, Sheffield, United Kingdom
- ¹³⁹Department of Physics, Shinshu University, Nagano, Japan
- ¹⁴⁰Fachbereich Physik, Universität Siegen, Siegen, Germany
- ¹⁴¹Department of Physics, Simon Fraser University, Burnaby BC, Canada
- ¹⁴²SLAC National Accelerator Laboratory, Stanford CA, United States of America
- ¹⁴³(a)Faculty of Mathematics, Physics & Informatics, Comenius University, Bratislava; (b)Department of Subnuclear Physics, Institute of Experimental Physics of the Slovak Academy of Sciences, Kosice, Slovak Republic
- ¹⁴⁴(a)Department of Physics, University of Johannesburg, Johannesburg; (b)School of Physics, University of the Witwatersrand, Johannesburg, South Africa
- ¹⁴⁵(a)Department of Physics, Stockholm University; (b)The Oskar Klein Centre, Stockholm, Sweden
- ¹⁴⁶Physics Department, Royal Institute of Technology, Stockholm, Sweden
- ¹⁴⁷Departments of Physics & Astronomy and Chemistry, Stony Brook University, Stony Brook NY, United States of America
- ¹⁴⁸Department of Physics and Astronomy, University of Sussex, Brighton, United Kingdom
- ¹⁴⁹School of Physics, University of Sydney, Sydney, Australia
- ¹⁵⁰Institute of Physics, Academia Sinica, Taipei, Taiwan
- ¹⁵¹Department of Physics, Technion: Israel Institute of Technology, Haifa, Israel
- ¹⁵²Raymond and Beverly Sackler School of Physics and Astronomy, Tel Aviv University, Tel Aviv, Israel
- ¹⁵³Department of Physics, Aristotle University of Thessaloniki, Thessaloniki, Greece
- ¹⁵⁴International Center for Elementary Particle Physics and Department of Physics, The University of Tokyo, Tokyo, Japan
- ¹⁵⁵Graduate School of Science and Technology, Tokyo Metropolitan University, Tokyo, Japan
- ¹⁵⁶Department of Physics, Tokyo Institute of Technology, Tokyo, Japan
- ¹⁵⁷Department of Physics, University of Toronto, Toronto ON, Canada
- ¹⁵⁸(a)TRIUMF, Vancouver BC; (b)Department of Physics and Astronomy, York University, Toronto ON, Canada
- ¹⁵⁹Faculty of Pure and Applied Sciences, University of Tsukuba, Tsukuba, Japan
- ¹⁶⁰Department of Physics and Astronomy, Tufts University, Medford MA, United States of America
- ¹⁶¹Centro de Investigaciones, Universidad Antonio Narino, Bogota, Colombia
- ¹⁶²Department of Physics and Astronomy, University of California Irvine, Irvine CA, United States of America
- ¹⁶³(a)INFN Gruppo Collegato di Udine, Udine; (b)ICTP, Trieste; (c)Dipartimento di Chimica, Fisica e Ambiente, Università di Udine, Udine, Italy
- ¹⁶⁴Department of Physics, University of Illinois, Urbana IL, United States of America
- ¹⁶⁵Department of Physics and Astronomy, University of Uppsala, Uppsala, Sweden
- ¹⁶⁶Instituto de Física Corpuscular (IFIC) and Departamento de Física Atómica, Molecular y Nuclear and Departamento de Ingeniería Electrónica and Instituto de Microelectrónica de Barcelona (IMB-CNM), University of Valencia and CSIC, Valencia, Spain
- ¹⁶⁷Department of Physics, University of British Columbia, Vancouver BC, Canada
- ¹⁶⁸Department of Physics and Astronomy, University of Victoria, Victoria BC, Canada
- ¹⁶⁹Department of Physics, University of Warwick, Coventry, United Kingdom
- ¹⁷⁰Waseda University, Tokyo, Japan
- ¹⁷¹Department of Particle Physics, The Weizmann Institute of Science, Rehovot, Israel
- ¹⁷²Department of Physics, University of Wisconsin, Madison WI, United States of America

- ¹⁷³Fakultät für Physik und Astronomie, Julius-Maximilians-Universität, Würzburg, Germany
- ¹⁷⁴Fachbereich C Physik, Bergische Universität Wuppertal, Wuppertal, Germany
- ¹⁷⁵Department of Physics, Yale University, New Haven CT, United States of America
- ¹⁷⁶Yerevan Physics Institute, Yerevan, Armenia
- ¹⁷⁷Centre de Calcul de l'Institut National de Physique Nucléaire et de Physique des Particules (IN2P3), Villeurbanne, France
- ^aAlso at Laboratório de Instrumentação e Física Experimental de Partículas - LIP, Lisboa, Portugal
- ^bAlso at Faculdade de Ciências and CFNUL, Universidade de Lisboa, Lisboa, Portugal
- ^cAlso at Particle Physics Department, Rutherford Appleton Laboratory, Didcot, United Kingdom
- ^dAlso at TRIUMF, Vancouver BC, Canada
- ^eAlso at Department of Physics, California State University, Fresno CA, United States of America
- ^fAlso at Novosibirsk State University, Novosibirsk, Russia
- ^gAlso at Fermilab, Batavia IL, United States of America
- ^hAlso at Department of Physics, University of Coimbra, Coimbra, Portugal
- ⁱAlso at Department of Physics, UASLP, San Luis Potosi, Mexico
- ^jAlso at Università di Napoli Parthenope, Napoli, Italy
- ^kAlso at Institute of Particle Physics (IPP), Canada
- ^lAlso at Department of Physics, Middle East Technical University, Ankara, Turkey
- ^mAlso at Louisiana Tech University, Ruston LA, United States of America
- ⁿAlso at Dep Física and CEFITEC of Faculdade de Ciências e Tecnologia, Universidade Nova de Lisboa, Caparica, Portugal
- ^oAlso at Department of Physics and Astronomy, University College London, London, United Kingdom
- ^pAlso at Group of Particle Physics, University of Montreal, Montreal QC, Canada
- ^qAlso at Department of Physics, University of Cape Town, Cape Town, South Africa
- ^rAlso at Institute of Physics, Azerbaijan Academy of Sciences, Baku, Azerbaijan
- ^sAlso at Institut für Experimentalphysik, Universität Hamburg, Hamburg, Germany
- ^tAlso at Manhattan College, New York NY, United States of America
- ^uAlso at School of Physics, Shandong University, Shandong, China
- ^vAlso at CPPM, Aix-Marseille Université and CNRS/IN2P3, Marseille, France
- ^wAlso at School of Physics and Engineering, Sun Yat-sen University, Guanzhou, China
- ^xAlso at Academia Sinica Grid Computing, Institute of Physics, Academia Sinica, Taipei, Taiwan
- ^yAlso at Dipartimento di Fisica, Università La Sapienza, Roma, Italy
- ^zAlso at DSM/IRFU (Institut de Recherches sur les Lois Fondamentales de l'Univers), CEA Saclay (Commissariat à l'Energie Atomique), Gif-sur-Yvette, France
- ^{aa}Also at Section de Physique, Université de Genève, Geneva, Switzerland
- ^{ab}Also at Departamento de Física, Universidade de Minho, Braga, Portugal
- ^{ac}Also at Department of Physics and Astronomy, University of South Carolina, Columbia SC, United States of America
- ^{ad}Also at Institute for Particle and Nuclear Physics, Wigner Research Centre for Physics, Budapest, Hungary
- ^{ae}Also at California Institute of Technology, Pasadena CA, United States of America
- ^{af}Also at Institute of Physics, Jagiellonian University, Krakow, Poland
- ^{ag}Also at LAL, Université Paris-Sud and CNRS/IN2P3, Orsay, France
- ^{ah}Also at Nevis Laboratory, Columbia University, Irvington NY, United States of America
- ^{ai}Also at Department of Physics and Astronomy, University of Sheffield, Sheffield, United Kingdom
- ^{aj}Also at Department of Physics, Oxford University, Oxford, United Kingdom
- ^{ak}Also at Institute of Physics, Academia Sinica, Taipei, Taiwan
- ^{al}Also at Department of Physics, The University of Michigan, Ann Arbor MI, United States of America
- * Deceased